FOOD TECHNOLOGY

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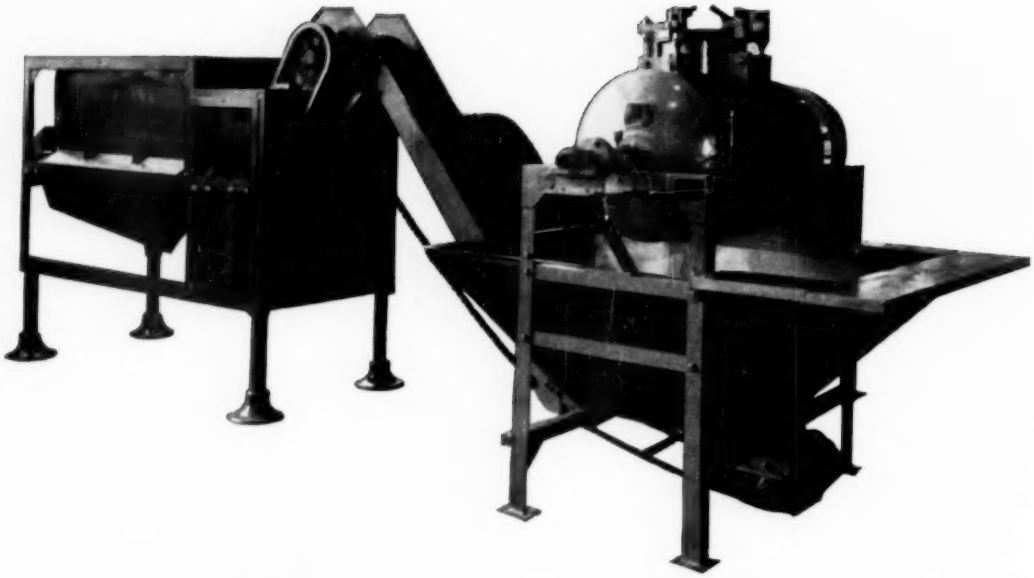

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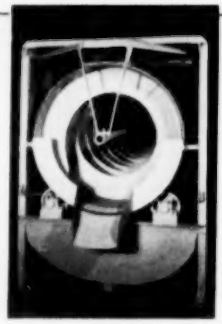

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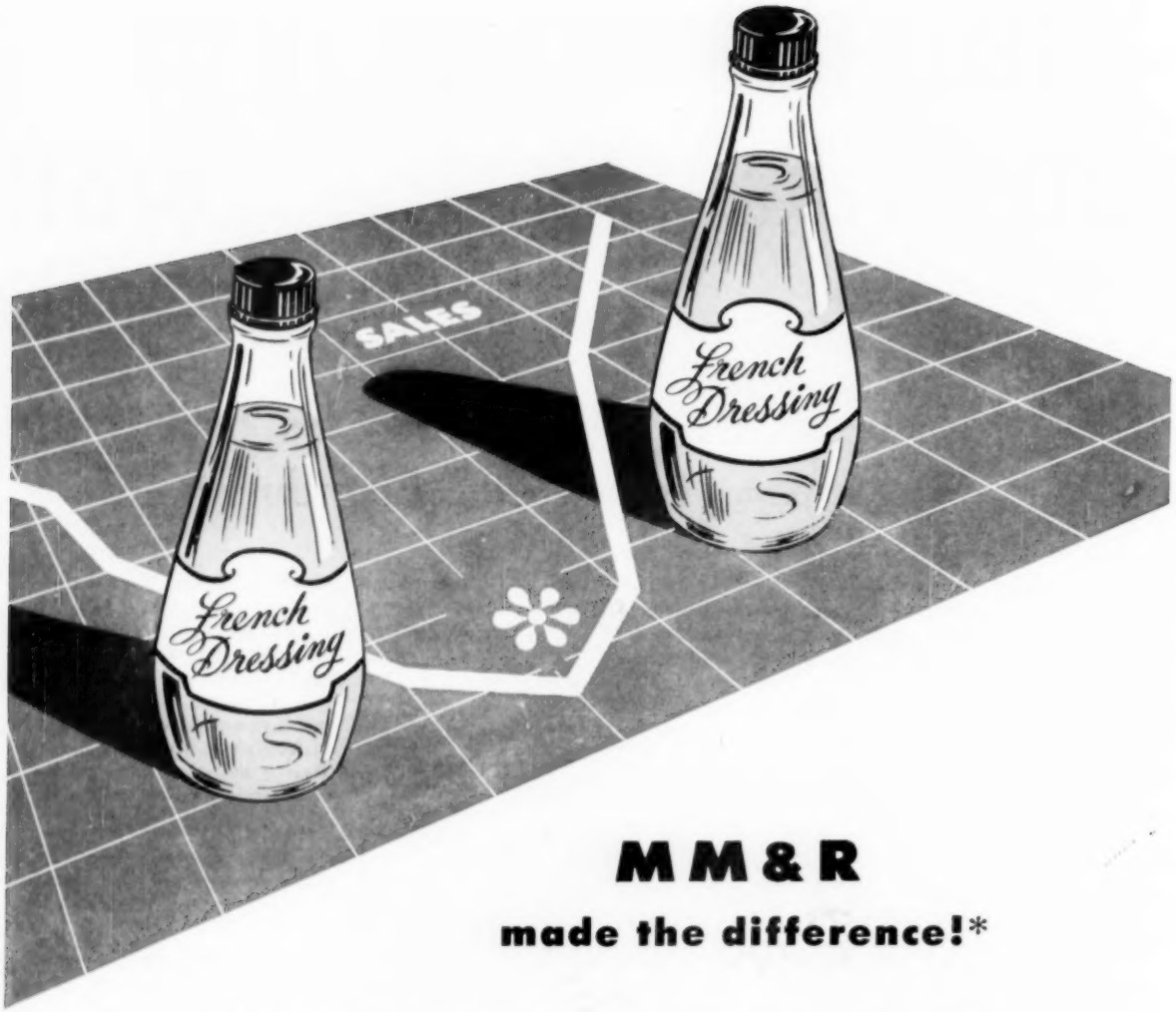

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The Institute of Food Technologists assumes no responsibility for statements in contributed articles appearing in FOOD TECHNOLOGY. Editorials present only opinions of the writers and do not necessarily reflect policies of the Institute of Food Technologists.

News in 1940—production necessity today

ONLY a few years ago, the science of sensitive, accurate measurement was limited to laboratories. But today, this science is practiced every day in thousands of industrial plants by factory men . . . who don't have to be instrument experts.

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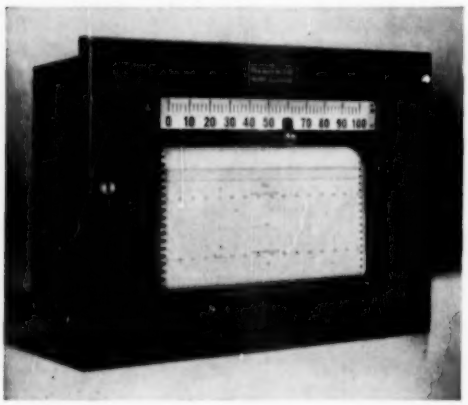

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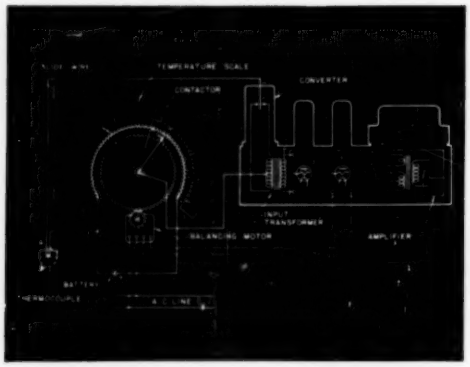

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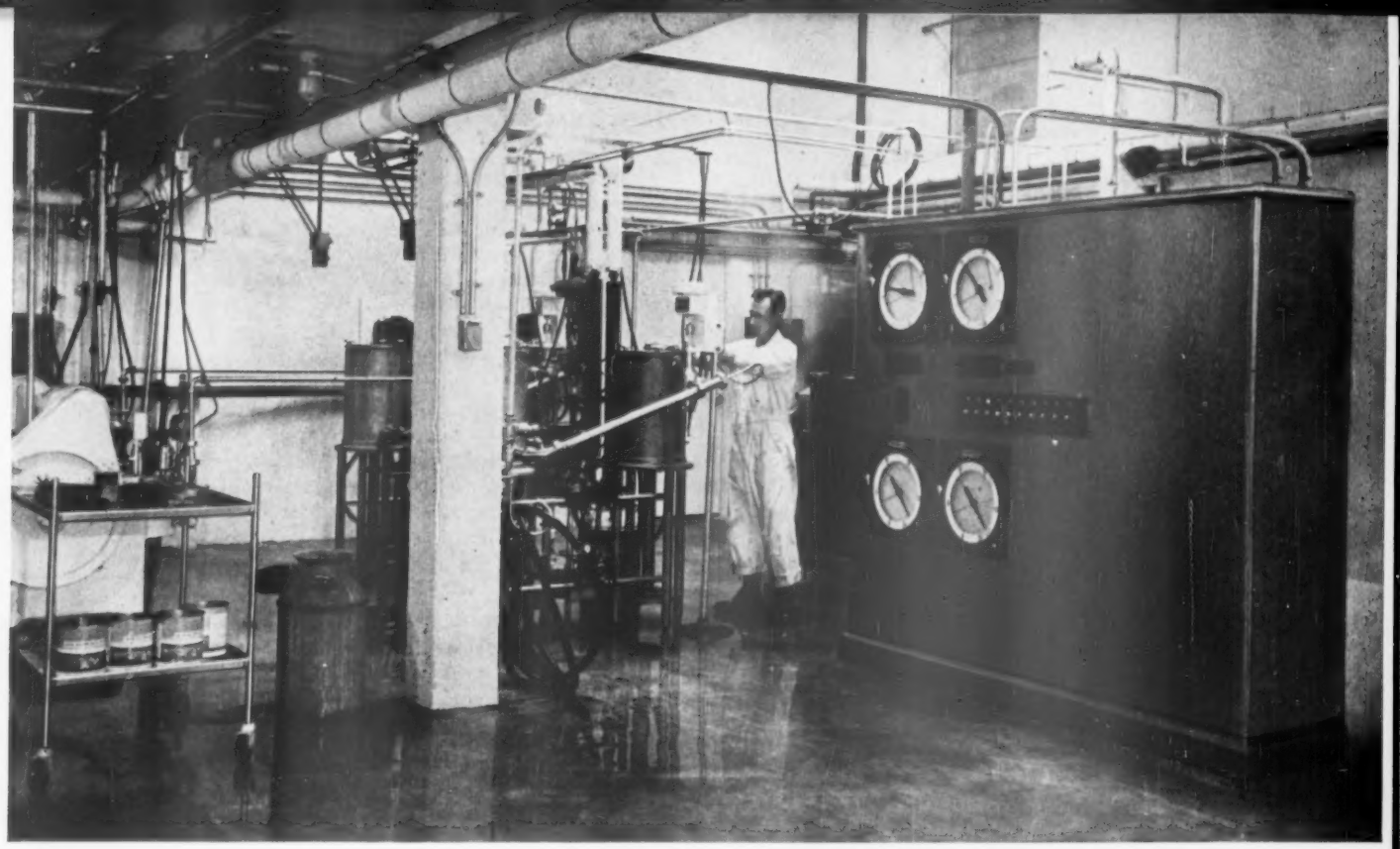

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Affairs of the Institute

Food Technology: An Informal Analysis of Its Readership
News of the Regional Sections
Personnel
Books
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Food World News
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Food Technology: An Informal Analysis of Its Readership

On the basis of a recent survey,* FOOD TECHNOLOGY would appear to be a congenial meeting ground for a great many professional people with diversified but nevertheless associated interests in food science. Food chemists, bacteriologists with primary interests in foods, food acceptance scientists, nutritionists, chemical engineers, food packaging engineers—these and more are represented in the subscribership. That FOOD TECHNOLOGY arrives at the desks of the executive group is made equally manifest by the survey—over 70% of the subscribers hold positions of that nature. Approximately 40% of the membership—from universities, research foundations, Government laboratories from the Atlantic to the Pacific—act as consultants in various highly specialized fields. In an era of specialism it is apparent that FOOD TECHNOLOGY is filling the need for a "pan-technological" medium in the food field. Of incidental importance, at least, is the fact that the efforts of the budding, as well as the seasoned, author appear to be reaching the "inner office," that is to say, the executive desk.

To the foregoing facts there should be added another; namely, that the survey shows that our subscribership is widely representative of the various commodity fields. In between the group of 595 persons identified with canning technology and the one person engaged in the development of perfumes are representatives of some twenty-five commodity classes. The exact distribution is shown in Table 1.

Subject Matter Coverage

Table 1, with its breakdown of the subscriber list, immediately suggests another topic—the extent to which FOOD TECHNOLOGY furnishes each of the various groups with technical information related to their field of specialization.

On the basis of 450 pages of FOOD TECHNOLOGY text, approximately the number of pages of technical material published during 1952, the distribution by fields of interest is that shown in Table 2.

(Continued on page 8)

* "Mail Survey of Membership, August, 1952," Gould, Gleiss and Benn, Inc. Respondents to the survey numbered about half the membership.

TABLE 1

Composition of Food Technology subscriber list as based on a mail survey of subscribers

	Total		Executive Position		Non-executive Position		Indeterminate combination of the two	
	No.	%	No.	%	No.	%	No.	%
Total respondents	2063	100.0	1477	71.6	376	18.2	210	10.2
Colleges, Research Foundations, Government Labs, Consultants	800	37.8	535	36.2	179	47.6	86	41.0
Canning	595	28.8	446	30.2	100	26.6	49	23.3
Freezing	355	17.2	271	18.3	50	13.3	34	16.2
Concentrating (evaporating)	319	15.5	249	16.9	45	12.0	25	11.9
Cereals (includes milling, baking, etc.)	308	14.9	235	15.9	54	14.4	19	9.0
Dairy Products	285	13.8	206	13.9	53	14.1	26	12.4
Meats—Meat Products	260	12.6	176	11.9	57	15.2	27	12.9
Dehydrating	231	11.2	185	12.5	28	7.4	18	8.6
Brewing and Beverages	228	11.1	176	11.9	34	9.0	18	8.6
Confections	187	9.1	156	10.6	19	5.1	12	5.7
Can Manufacturing (and other containers)	55	2.7	33	2.2	13	3.5	9	4.3
Drugs—Chemicals	26	1.3	16	1.1	10	2.7	—	—
Food Processing Equipment	22	1.1	20	1.4	1	0.3	1	0.5
Food Preservatives, Extracts	20	1.0	15	1.0	5	1.3	—	—
Sugar, Starch, Molasses, Syrup Production	19	0.9	11	0.7	5	1.3	3	1.4
Preserves, Jellies, Spices, Vinegar	17	0.8	15	1.0	1	0.3	1	0.5
Fats and Oils	15	0.7	13	0.9	1	0.3	1	0.5
Food Packaging	14	0.7	9	0.6	3	0.8	2	1.0
Margarine, Salad Dressing, Peanut Butter	14	0.7	12	0.8	—	—	2	1.0
Brokers, Jobbers, Suppliers	12	0.6	7	0.5	3	0.2	2	1.0
Vitamins, Plant Derivatives, Yeast	10	0.5	9	0.6	1	0.3	—	—
Food Processing (unspecified)	7	0.3	6	0.4	1	0.3	—	—
Fishery Products	6	0.3	5	0.3	1	0.3	—	—
Cocoa and Chocolate Processing	5	0.2	3	0.2	2	0.1	—	—
Retail Food Distribution (and transportation)	4	0.2	3	0.2	—	—	1	0.5
Service and Maintenance	3	0.1	3	0.2	—	—	—	—
Gelatine (food, pharmacy, photography)	2	0.1	2	0.1	—	—	—	—
Pet Food	2	0.1	2	0.1	—	—	—	—
Publishing	2	0.1	2	0.1	—	—	—	—
Soaps	2	0.1	2	0.1	—	—	—	—
Engineering	1	0.1	1	0.1	—	—	—	—
Perfumes	1	0.1	1	0.1	—	—	—	—
Trade Associations	1	0.1	1	0.1	—	—	—	—
Not Specified	27	1.3	17	1.2	6	1.6	4	1.9

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Food Technology: An Informal Analysis of Its Readership

(Continued from page 6)

In arriving at the figures in Table 2 certain arbitrary judgments have been made. Taken into consideration were (a) the major problem discussed, (b) the purpose of the article—i.e., whether the intent in a given case was to report data on a biochemical problem or to use such data to point up a food acceptance study—and (c) the procedures involved. It is not maintained that all who attempt to chart the distribution of subject matter in FOOD TECHNOLOGY through 1952 will come up with the same figures. It can be said with considerable asurance, however, that the distribution falls roughly within the pattern apparent in Table 2.

TABLE 2

Distribution of pages by fields of interest

Subject matter	Pages	Percentage of total pages
Biochemistry	99	22
Food Engineering	83	18
Bacteriology	79	18
Quality Control	63	14
Management	40	9
Food Acceptance	37	8
Food Economics	31	7
Food Packaging	18	4
Totals	450	100

Of equal interest is the distribution of subject matter in terms of commodities. Allocation of pages to the various commodity groups is shown in Table 3.

TABLE 3

Distribution of pages by commodity groups

Products	Pages	Percentage of total (450)
Fruit	80	18
Vegetable	77	17
Meat	50	11
Poultry	31	7
Fish	21	4.5
Cereal	13	3
Dairy	4	1
Confections	9	2
Yeast	9	2
Spices	6	1.5
Non-commodity	150	33
Totals	450	100

As in Table 2, the figures contained in Table 3 are rather arbitrarily derived, and different accountants could justifiably come up with different patterns of distribution. In some articles, for example, both fruit products and vegetable products may be discussed, and determining the precise space given to each leads immediately into imponderables. It seemed expedient, if not statistically defensible, to solve such problems by splitting the difference. The only alternative technique would be to employ the crystal ball—in conjunction with the calculus. Again, however, the figures obtained are at least roughly representative of the allocation of pages to the various commodity groups.

Concluding Observations

Any attempt to relate *quid pro quo* the subject matter distribution of FOOD TECHNOLOGY to the distribution of the various professional groups composing the subscriber list would be suspect at every turn because of the primary difficulty of delimiting the interests of any one group. For example, almost half of the subscribers appear to be identified with the canning or freezing industries, and somewhat more than half of the subject matter is related to commodities which are most commonly either canned or frozen (fruit, vegetables, meat, poultry, fish). This appears to be a fortuitous adjustment of subject matter to professional interest, but of course the situation is only relatively thus neat. Not all of the articles deal with processing problems for one thing, and for another many other groups besides those mentioned—for example, the executive group generally—would have a distinct interest in this subject matter. Perhaps, pending more extensive analysis, the chief conclusion to be drawn from these tables is that our subject matter is diversified, that it is reasonably well adjusted to the varied professional fields represented by our readership, and that FOOD TECHNOLOGY can be regarded as an effective medium for integrating the diverse technological advances being made by the food industries and by public and private research and development organizations over America and abroad. M. S. P.

Regional Section News

CHICAGO SECTION

The December meeting was set aside as a "Ladies' Night." We were glad to see so many ladies present. The program consisted of an interesting as well as informative discussion and demonstration on the "Art of Carving" by Paul Goeser. He first discussed the sometimes difficult situation between host and hostess concerning various phases of carving for a dinner party such as, shall the carving be done in the kitchen, and can the host stand at the table during carving. This was followed by discussion of the art and then a demonstration on actual products including baked ham, beef roast, T-bone steak and turkey. The subject was very ably covered. In the future we should have less difficulty in demonstrating our own ability.

Mr. Goeser was born in Burlington, Iowa and received his B.S. and M.S. degrees from Iowa State College. After one year of teaching he spent 12 years in meat lecture demonstration work throughout the United States for the National Livestock and Meat Board. During World War II he helped develop the meat training program for the Armed Forces. At the present time Mr. Goeser is in charge of the Fresh Meats Research Division of Swift and Company's Research Laboratories.

The results of the election of officers were reported by the Chairman of the Tellers Committee as follows:

Chairman—George E. Brissey, Swift and Co.
Vice-Chairman and Section Councilor—Stanley F. Brockington, Quaker Oats Co.
Secretary—Lloyd E. Slater, Food Engineering.

(Continued on page 10)

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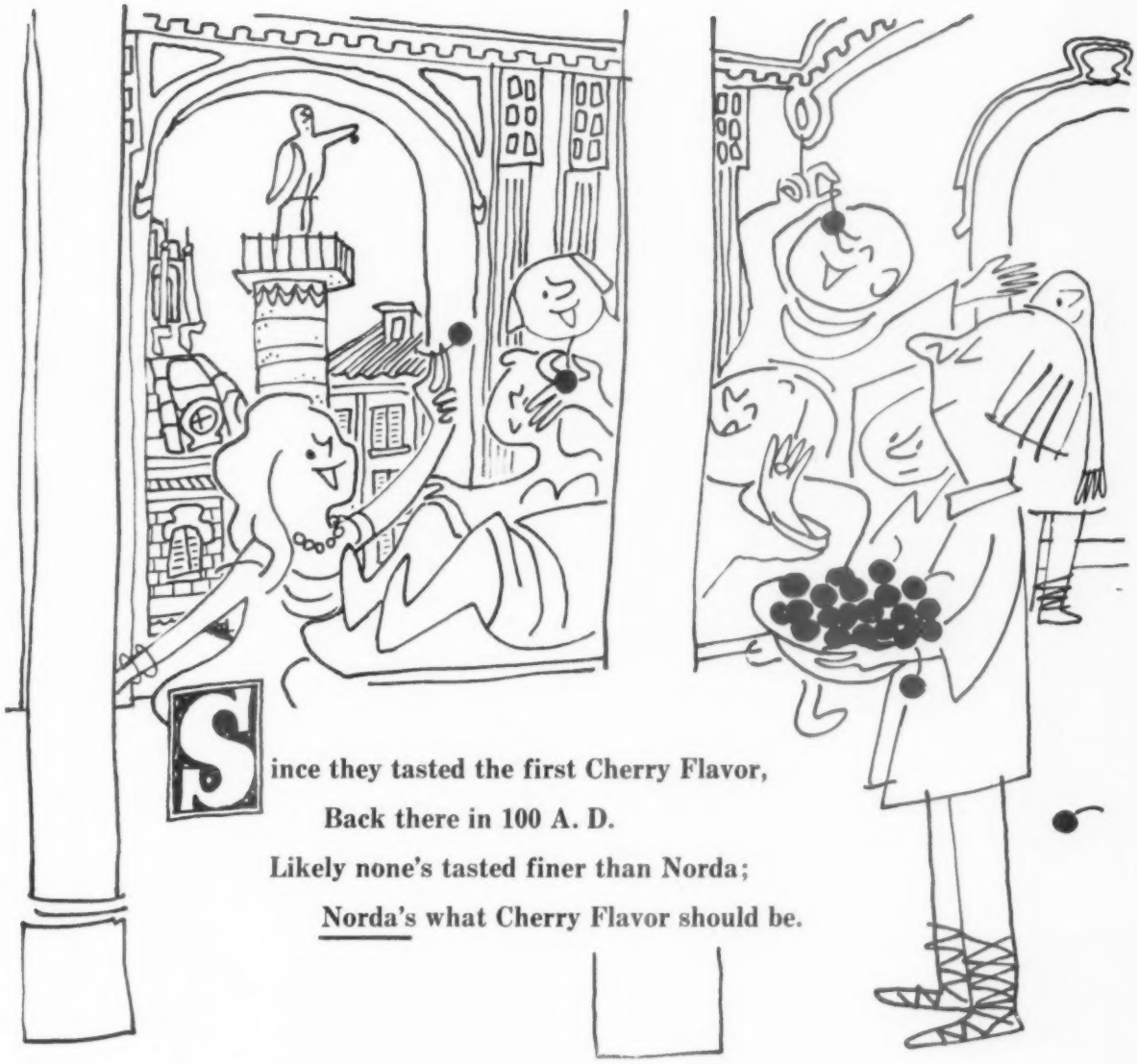

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Regional Section News

(Continued from page 8)

Treasurer—E. W. Hopkins, Armour & Co.
Executive Committee 1953-54—Ed Schoenfeld, Wm. J. Stange Co.; Al Edgar, Wilson & Co., Inc.
Section Councilors 1953-54—R. J. Cohee, Corn Products Sales; Dorothy Ann Huber, Q. M. Food and Container Institute.

DIXIE SECTION

The January meeting was held at the Atlanta Paper Company's plant, one of the South's largest manufacturers of corrugated boxes, folding cartons, bottle carriers and many other items. After a tour of the plant dinner was served in the plant cafeteria. Mr. Norman S. Epped, Quartermaster Food and Container Institute, was the speaker.

MARYLAND SECTION

The Annual Meeting and Ladies' Night of the Maryland Section, IFT, was held Friday, December 12, at the Hotel Stafford, Baltimore, Md. According to custom, the Annual Address was presented by retiring chairman of the Section, Dr. B. W. Clarke, of Crosse and Blackwell, who titled his talk "The Reminiscences of an Imported Food Technologist." Officers elected for the year 1953 were:

Chairman—Edgar Heyl, Crown Cork & Seal Co., Baltimore, Md.
Vice-Chairman—Arthur M. Kaplan, U. S. Department of Agriculture, Beltsville, Maryland.
Secretary—Leroy V. Strasburger, Strasburger and Siegel, Baltimore, Md.
Treasurer—William A. Feild, Federal Yeast Corporation, Baltimore, Md.
Member of the Executive Committee—W. E. Lamble, Jr., Southern Packing Co., Baltimore, Md.
Councilors—Albin H. Warth, Crown Cork and Seal Co., and Basil W. Clarke, Crosse and Blackwell Co., Baltimore, Md.

The door prize, a case of tomato juice, was contributed to the meeting by the Southern Packing Company of Baltimore, Md.

MOHAWK VALLEY SECTION

The Section met in Canajoharie, New York on December 9 at the Fort Rensselaer Club. Mr. William D. Rinck of the Reynolds Metals Company, New York City, New York was the dinner speaker. Two short movies were shown "Packaging Pay Off" and "Pigs in Progress."

A short business meeting was held and the results of the annual election of officers were announced:

Chairman—David S. Luscombe, Beech-Nut Packing Company, Canajoharie, New York.
Vice-Chairman—Michael L. Kubovciak, Beech-Nut Packing Company, Canajoharie, New York.
Recording Secretary—Margaret C. French, Beech-Nut Packing Company, Canajoharie, New York.
Corresponding Secretary—Maxine C. Baker, Beech-Nut Packing Company, Canajoharie, New York.
National Councilor—Edwin J. Abeling, Beech-Nut Packing Company, Canajoharie, New York.

PHILADELPHIA SECTION

The Section's January meeting took the form of a Ladies' Night, and was held on January 8th at the Drexel Institute in Philadelphia. The after dinner speaker was Dr. W. L. Obold, of Drexel Institute, who discussed some aspects of "Egyptian Life" as he sensed it from his sojourn in that country during the past year.

Mr. Harry W. Von Loesecke, Acting Assistant Chief of the Bureau of Agriculture and Industrial Chemistry of the United States Department of Agriculture, addressed the evening meeting on the subject "Some Trends in Food Dehydration." He also showed a sound movie in color, "Middle America," giving the story of the banana as well as of the peoples of Central America. Mr. Von Loesecke is the author of the well known book "Drying and Dehydration of Foods," and is a past member of the Editorial Board of Food Technology.

PERSONNEL

C. Hamilton Kenney, member of the Editorial Board of Food Technology in charge of Regional Section News and Personnel, last month was appointed Editor of *Professional Public Service*, official journal of the Professional Institute of the Public Service of Canada. In real life, Mr. Kenney is an Editor with the Information Service of the Canada Department of Agriculture, Ottawa.

Lt. Col. Charles A. Shaunesey, Commandant of the Qm. Food and Container Institute for the Armed Forces, Chicago, ended his assignment there on January 20, 1952. He is being succeeded by Lt. Col. George McAneny, who has been the executive officer of the Institute for the past several months.

Professor F. H. Reuter of the Food Technology Department, New South Wales University of Technology, Sydney, has taken up residency at the Massachusetts Institute of Technology, where he is undertaking advanced work. Prior to arriving in Boston, Professor Reuter availed himself of the numerous opportunities provided him to visit and study processing plants across America. Included were numerous food research organizations both public and private. Dr. Reuter is the Editor-in-Chief of Food Technology in Australia.

Books

Biochemical Preparations. Volume 2. Eric G. Ball, Editor-in-Chief. John Wiley and Sons, Inc., New York. 109 pages. $3.00.

This volume, the second of a series, constitutes a very worthy contribution to the vitally needed biochemical counterpart of *Organic Synthesis*. The appearance of the volume was delayed by the untimely death of the intended Editor-in-Chief, Robert C. Sealock. E. G. Ball, however, assumed the editorial task, a task well done.

As in *Organic Synthesis*, a highly refined preparative method developed and submitted by one laboratory is checked independently by another. This scheme assures the applicability of the methods and, for the most part, even the uninitiated should be able to utilize them successfully.

Covered in this volume are the preparation of cytochrome *c*, cucurbit seed globulin, oxycasein, phosvitin,

(Continued on page 14)

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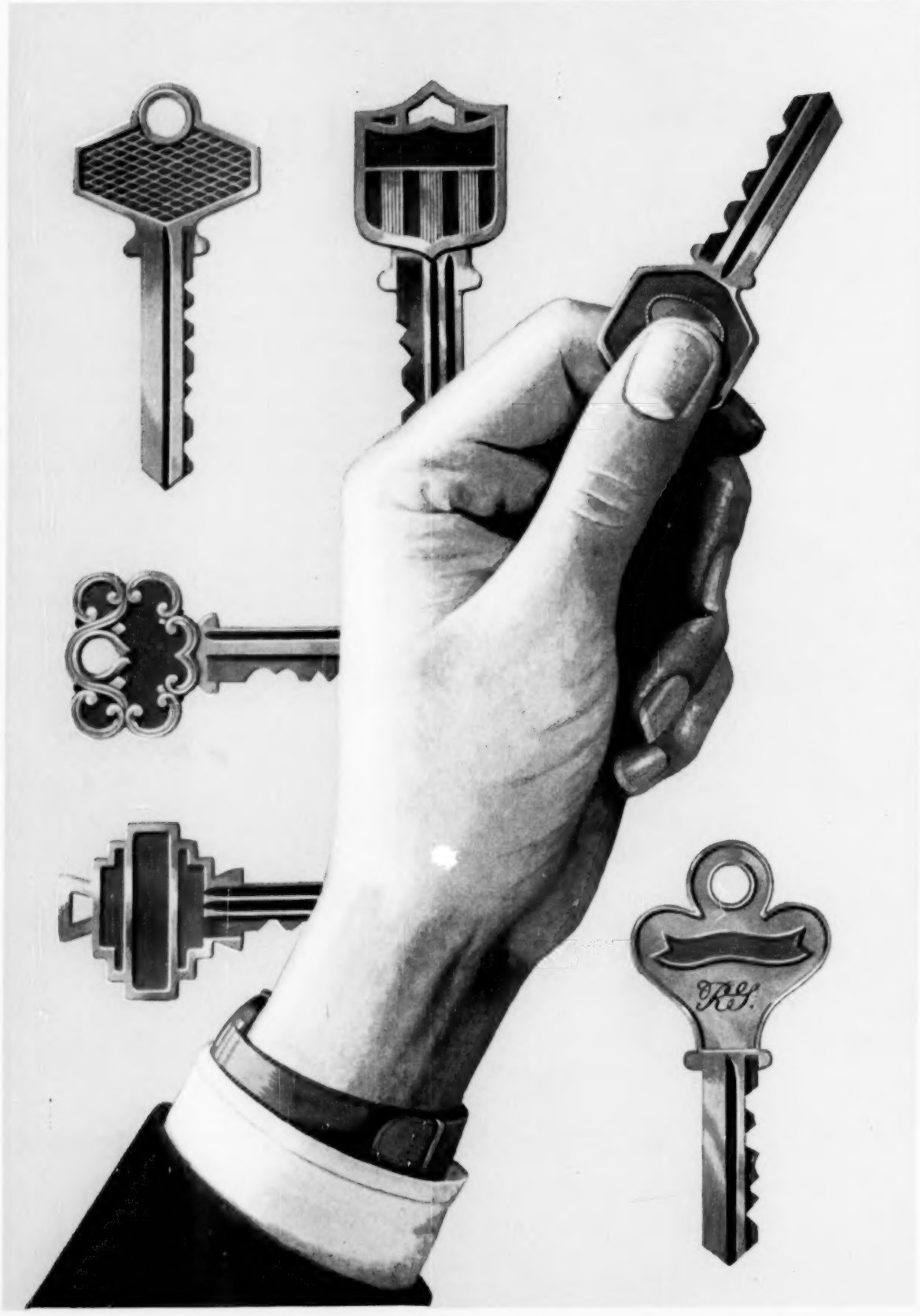
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Books

(Continued from page 10)

crystalline lactate dehydrogenase, sodium pyruvate, phosphoryl-enolpyruvic acid, L-α-glycerophosphoric acid, glucose-6-phosphate, C^{14} uniformly labeled sucrose, fructose-1, 6-diphosphate, *myo-* and DL-*epi*-inosose-2, inositol monophosphate, DL-glutamic acid, L-aspartic acid, glutathione synthesis and the intermediates involved, reduced diphosphopyridine nucleotide, phosphorylcholine, oleic acid and methyl oleate, and methyl ricinoleate.

The requisition of this book by all scientific biological libraries is essentially mandatory. The food scientist will find some of these preparations useful as specific reagents in studies of the fundamental biochemistry of raw foods or the changes that occur during storage and processing. EUGENE F. JANSEN.

THE YEASTS. Edited by J. Lodder and N. J. W. Kreger-van Rij. Interscience Publishers, Inc., New York. Price, $19.80.

This new book, written in English, is much more than a translation and combination of the separate monographs previously contributed by the outstanding group of Dutch yeast taxonomists,—a school which claims such outstanding names as Kluyver, Berkhout, Stelling-Dekker, Lodder, Diddens, and Kreger-van Rij. The book is worthy of its traditions.

The Dutch authors have extended the ascosporogenous family *Endomycetaceae* to contain the subfamilies *Eremascoideae*, *Endomycetoideae*, *Saccharomycetoideae*, *Nematosporoideae*, and the new subfamily *Lipomycetoideae*. Two of the 4 genera of the family *Sporobolomycetaceae*, namely *Sporobolomyces* and *Bullera*, are brought into the yeasts. The asporogenous yeasts comprising the *Cryptococcaceae* consist of the subfamilies *Rhodotoruloideae*, *Trichosporoideae*, and *Cryptococcoideae*. The last named contains such well known groups as *Candida* and *Torulopsis*, the latter genus now appearing as two autonomous genera named *Cryptococcus* and *Torulopsis*.

To cover briefly a book as comprehensive as this one, it may be profitable to limit the discussion to notes on some genera, particularly to changes which the Dutch authors have made, and to the ease of identifying isolates. Ascosporogenous genera will be mentioned first.

Endomyces retains its usual definition, but is no longer regarded as belonging to the yeasts. It is discussed briefly because of its relationship to *Schizosaccharomyces*. *Schizosaccharomyces* is broadened to include species which form mycelium. *Endomyces* is distinguished from *Schizosaccharomyces* by formation of asci from specialized cells. Species of *Endomycopsis*, all of which produce true hyphae, may be differentiated from species of the two preceding genera by its production of blastospores.

The genus *Saccharomyces* now includes *Zygosaccharomyces*, *Torulaspora*, and the fermentative species formerly placed in *Debaryomyces*. The nonfermentative species of *Debaryomyces* retain their former generic name. *Pichia* and *Hansenula* now contain the species previously placed in *Zygopichia* and *Zygohansenula*, respectively. The new genus *Lipomyces* consists of the two fat-producers, *L. lipofera* and *L. starkeyi*. One of the unusual characteristics of the genus is the formation of asci with more than 8 spores.

The ballistospores of *Sporobolomyces* are asymmetrical, kidney-shaped or sickle-shaped, and cultures are red to salmon-pink. *Bullera* is distinguished by symmetrical, round or oval spores, and cultures are pallid, pale yellow to yellowish.

Some significant changes have been made among the nonascosporogenous yeasts. *Mycoderma* is reduced to a single species, and it has been transferred to *Candida*. The degree of mycelium formation has been lowered for admission to *Candida*, and the food yeast formerly known as *Torulopsis utilis* has been transferred to it. *Cryptococcus* as now defined contains nonfermentative species which are capsulated and synthesize starch. *Torulopsis*, on the contrary, is composed of species some of which may be nonfermentative and exceptional species may have encapsulated cells, but starch is not synthesized by any of the species. A very primitive pseudomycelium may rarely be found. Species with a stronger tendency to form mycelium are placed in *Candida* whether or not they have the ability to synthesize starch.

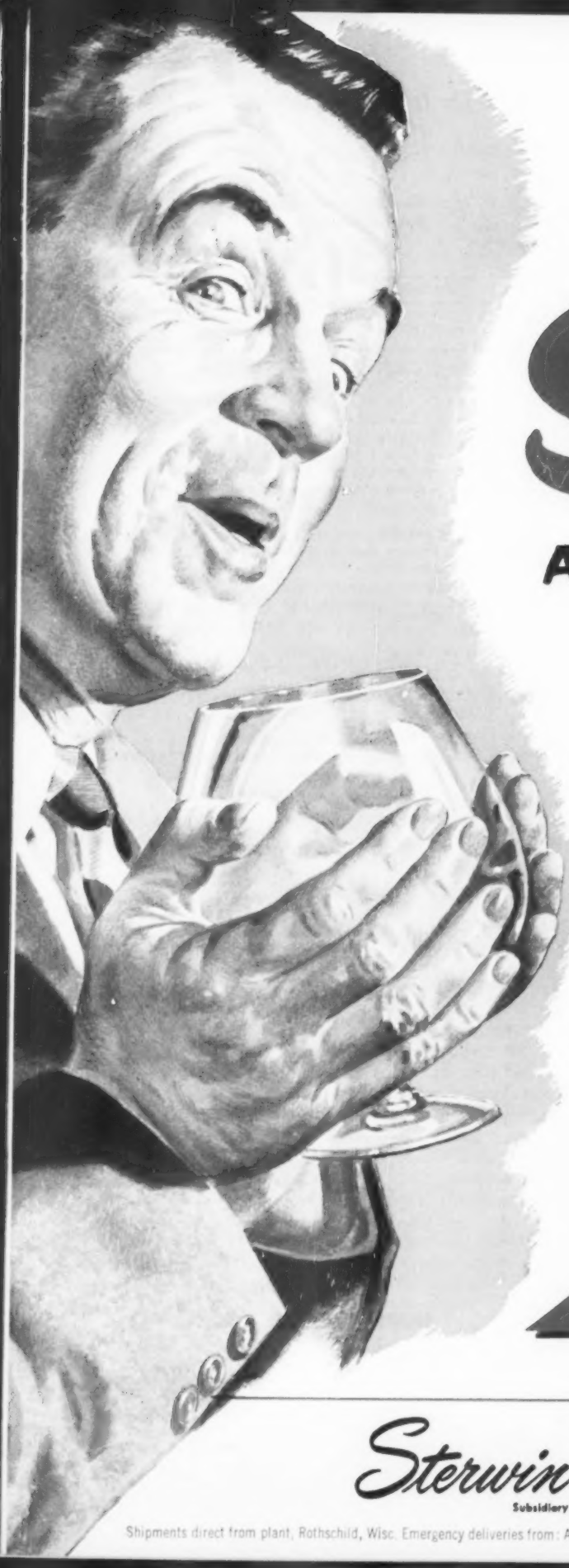
It is probable that the new classification of Lodder and Kreger-van Rij has not made easier the generic placement of isolates, but once the genus has been determined, species placement should be more readily accomplished than was possible before this book appeared. Some of the factors permitting easier placement within the genus may be exemplified by the following:

The number of osmophilic *Saccharomyces* (from the former subgenus *Zygosaccharomyces*) has been greatly reduced. The number of species in several other genera have also been reduced. Certain variable characteristics given weight in previous classifications, such as various tints or shades of color in *Rhodotorula*, are now given much less weight. Relatively greater weight is now placed on carbon assimilation reactions. Since the number of carbon sources used in these tests is quite small, the number of species recognized in such genera as *Rhodotorula* and *Trichosporon* is also quite small. The field worker who merely wants a name for his isolate may be quite content with this situation, but some taxonomists may feel that too many species remain unrecognized. However deep one's interest may be, the new book by Lodder and Kreger-van Rij is so full of information that despite its cost, no yeast taxonomist can afford to be without it. L. J. WICKERHAM.

TOWNSMAN'S FOOD. Magnus Pyke. 207 pp. Turnstile Press, London 1952.

The author's stated objective is to show what has happened to foods during processing for distribution to the people of urban centers. The book is for the general reader reather than for scientists and technologists and describes some of the technical problems of the modern food industry. Considerable attention is given to the defense of the regulating measures taken by the several agencies of the British Government to assure equitable and safe distribution of food in Britain during the last

(Continued on page 18 following technical papers)



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A. It is vitamin A, the product of a synthesis which starts with Citral, from lemon grass oil. It is identical biologically with the vitamin A from other sources, such as fish livers. A Roche research team directed by Dr. Otto Isler announced their famous synthesis in 1947. This successful, economical process is now used to produce vitamin A of superb quality by the tons at Roche Park.

Q. *Does Roche vitamin A have a "fishy" odor or taste?*

A. None whatever, nor is there any "fishy burp." In fact, Roche vitamin A has almost no odor or taste and so is preferred for processed foods such as margarine.

Q. *Will I be able to get a steady supply of Roche vitamin A?*

A. You will. The entire commercial needs of the food and pharmaceutical industries of the United States and Canada could be met from our Nutley plant.

Q. *Can I be sure of a "standard" product?*

A. You can. Roche vitamin A is manufactured under strict laboratory control. It is more stable. It is uniform. The regular commercial types of Roche material, if diluted to 50,000 to 65,000 units per gram, will meet the specifications of U.S.P. XIV for oleovitamin A. It is a product of excellent quality.

Q. *What about price?*

A. Roche vitamin A is not subject to wide fluctuation of price, as has been true with vitamin A from natural sources. This can mean large savings for you as there is no need to carry large inventories as was the case prior to the introduction of Roche vitamin A in 1950. Never before has the purchaser been assured of such low prices, consistent with quality and uniformity.

Q. *How is Roche vitamin A packed?*

A. All Roche vitamin A is packed under conditions which assure its stability in customary shipment and storage.

Q. *Can I get help from Roche in using vitamin A in my products?*

A. Yes, certainly! Roche technical experts who supplied so much data at the hearings for amended Definitions and Standards of Identity for Margarine are always at your service. It is important to you that Roche specializes in the manufacture of vitamins.

Q. *Is Roche vitamin A available in different types and potencies?*

A. It is. The following table shows the types most popular in food manufacturing.

TYPE	DESCRIPTION	POTENCY	ADDITIVE*
P1MO	Vitamin A palmitate	1,000,000 U.S.P. XIV units per gram	Edible oil only for standardization
P1.3	Vitamin A palmitate	Ranging between 1,250,000 and 1,500,000 U.S.P. XIV units per gram	None
A1MO	Vitamin A acetate	1,000,000 U.S.P. XIV units per gram	Edible oil only for standardization

*Antioxidants or other additives are included on customer's specifications.

Notes: Type P1MO has less tendency to crystallize during storage and handling than higher concentrations of vitamin A palmitate and acetate.

Type P1.3 is more susceptible to crystallization than type P1MO but can be handled without difficulty when using certain precautions.

Q. *Are special blends available for the margarine industry?*

A. Yes. Roche will supply blends to your specifications. A modern blending and canning plant is at your service.

Q. *What kind of service can I expect on special blends?*

A. The best—with special attention to accuracy, quality and control.

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Factors Affecting the Microbiological Populations of Shell Eggs[a,b]

RICHARD H. FORSYTHE,[c] JOHN C. AYRES, AND JASON L. RADLO[d]
Departments of Poultry Husbandry and Bacteriology, Iowa State College, Ames, Iowa

(Manuscript received June 24, 1952)

One of the major problems in the marketing of shell eggs is the loss sustained by producers, processors, and consumers from the production and subsequent handling of dirty eggs. Data are presented showing the amount of initial microbial contamination of the exterior and interior of clean and dirty eggs. The effects of the storage, sweating, and washing of these eggs on the microbiological populations are reported. It is concluded, on the basis of the laboratory results, that the cleaning of dirty eggs can result in improved sanitary quality. The need for a comprehensive commercial trial with adequate bacteriological examinations is emphasized.

One of the major problems in the marketing of shell eggs is the loss sustained by producers, processors, and consumers from the production and subsequent handling of dirty eggs. It has been estimated *(2)* that 17% and, in certain seasons, as many as 25% of all eggs produced in the Midwestern area must be classed as stains or dirties. Two aspects of the problem merit consideration, a, serious losses result from the actual spoilage of eggs in marketing channels and b, a sanitation and public health menace exists due to the presence of several types of human pathogens.

The complexity of this problem may be estimated by an examination of the voluminous literature concerned with the microbiology of shell eggs and, more specifically, with the effects of washing shell eggs on their storage life. There appears to be little uniformity in the results of many reports and the conclusions as to the proper methods of handling dirty eggs are conflicting. These widely divergent conclusions are due partly to the fact that many investigators have worked with eggs of unknown history and have concerned themselves with the effects as measured by candling or other subjective measures of inedibility rather than by the more objective procedures of ascertaining the numbers of organisms on and in the shell eggs and then studying the effect of various handling and processing treatments on these microbial populations. The more time consuming and tedious procedures involved in making bacterial counts on the eggs, while limiting the total number of eggs that can be examined, appear to be of more value in predicting the effects to be expected in the commercial handling of shell eggs.

This study was instigated to examine the initial microbiological populations on and in shell eggs and to investigate the factors influencing the penetration and subsequent multiplication of microorganisms in shell eggs. The factors studied include initial contamination, washing, sweating, and the temperature and humidity of storage.

The absence of a critical evaluation of the existing literature is not intended to minimize its usefulness but rather to eliminate the confusion that results from attempts to correlate and draw conclusions from the widely different types of researches reported. Haines *(5)*, Tanner *(10)*, and Romanoff and Romanoff *(7)* have adequately reviewed the pertinent literature related to the microbiology of shell eggs up to the time that their publications appeared.

EXPERIMENTAL PROCEDURE

All of the eggs used in these experiments (with the exception of those used to determine the incidence of spoilage in commercial dirty eggs) were secured from the Iowa State College Poultry Farm within 8 hours after laying. Although most of the eggs obtained during each laying season were obtained from the same pen of birds, preliminary examinations indicated differences between eggs from the same pen were as large as between eggs from different pens. No consistent effort was made to control the pen source. All birds were kept on ground corn cob floor and nest litter. Management practices were those recommended by the Iowa State College Extension Service and resulted in a minimum of heavy-dirty eggs. Eggs were gathered twice daily and held at 13° C. (55° F.) in wire baskets until used for the experiments.

Eggs were washed by light "hand" brushing (with rubber gloves) while a stream of water (and soap, detergent, or germicide*) flowed onto the egg from a container maintained at 43° C. (110° F.) by a thermostatically controlled electric immersion heater. In several experiments this procedure was replaced by a soaking period at the same temperature. These techniques resulted in visibily clean eggs in all cases. The eggs were allowed to air dry in front of a fan without further rinsing, and were stored in new, clean one-dozen cartons or fillers and flats.

Eggs were stored in two ways. Large (case) quantities were stored in an insulated room equipped with mechanical refrigeration and thermostatic controls capable of maintaining the storage space at 0.5° C. ± 0.6° (33° F. ± 1°). Humidity was regulated and recorded by an American Instrument Company Electric Hygrometer. Constant air circulation was provided and cases were stacked to permit free exchange of air. Small lots of eggs were held in desiccators above appropriate solutions of sulfuric acid to give the desired relative humidities. The desiccators were placed in laboratory incubators maintained at the desired temperatures.

Determination of the number of microorganisms on the outer shell surface was made by washing eggs in a Waring Blendor in

[a] Presented at the Twelfth Annual Meeting of the IFT, Grand Rapids, Michigan, June 11, 1952.

[b] Journal contribution from the Iowa Agricultural Experiment Station Project 1174.

[c] Present address, Armour and Company, Chicago, Illinois.

[d] Present address, Brookline, Massachusetts.

* Three washing materials were used in these studies. Their compositions as furnished by the manufacturers are as follows:

Vel—primarily a neutral sulfated monoglyceride; manufactured by Colgate-Palmolive-Peet Company.

Roccal—primarily a mixture of high molecular weight alkyldimethylbenzyl ammonium chlorides; manufactured by Winthrop-Stearns, Inc.

Kleneg—primarily a mixture of tetra-sodium-pyrophosphate; sodium salt of oleic acid; trimethyloctadecenyl and trimethyloctadienyl ammonium chlorides; manufactured by Armour and Company.

The use of these compounds in no way constitutes an endorsement of these products by the Iowa State College.

accordance with the procedure described by Rosser *(8)*. Aliquots of the wash water were placed in petri dishes, covered with nutrient agar and the dishes incubated at 25° C. (77° F.) for 72 hours. Several other media including nutrient agar enriched with yeast extract and tryptone glucose agar were employed but since no consistent increases in counts were obtained the standard nutrient agar medium was used for all routine shell surface examinations. Bacteria, yeast, mold, and actinomycete colonies were counted collectively and no attempts were made to determine relative numbers.

Several procedures were examined for their effectiveness in "sterilizing" the shell prior to opening and removing the contents for bacterial counts. The following procedure consistently gave the most satisfactory results, and was employed in the majority of the experiments reported here:

> Individual eggs were soaked in 0.5% Kleneg at 43° C. (110° F.) for 2-3 minutes and lightly brushed when necessary to remove large dirt particles. The eggs were then rinsed with sterile distilled water at 43° C. (110° F.) and placed in a Roccal solution (1200 p.p.m.) at 43° C. (110° F.) for ten minutes. The eggs were again rinsed with the sterile distilled water and placed in ethyl alcohol (70% by weight) at 43° C. (110° F.) for one minute. After removal from the alcohol, the eggs were flamed and placed between sterile towels until opened. The effectiveness of this procedure was evaluated by placing the entire shell and membranes in special sterility broth and incubating at 25° C. (77° F.) for four days. Approximately half of the "sterilized" shells examined were found to be bacteriologically sterile. This appears to be considerably more satisfactory than the methods previously described in the literature.

Egg contents were removed by a procedure similar to that described by Wolk, McNally and Spicknall *(12)* in which a portion of the shell in the small end of the egg was removed (with the aid of sterile forceps) and the broken edge of the shell flamed. The egg was then inverted over a sterile receptacle and the contents forced out by applying a flame to the air cell end of the egg.

In most of the experiments reported here the bacterial counts on the egg contents were obtained by using the "most probable numbers" technique *(1)*. Nutrient broth was used in the preliminary portion of these studies, but a special sterility medium was found to give higher counts and was used for determining a major part of the bacterial counts. This medium was prepared as follows:

Phenol red dextrose broth (Difco)	21 gms.
Yeast extract	5 gms.
Brom cresol purple (1.6% in alcohol)	1 ml.
Water	1000 ml.

pH 6.8-7.0

The entire egg contents of each egg were shaken vigorously in a glass jar containing pieces of broken glass; and then 10 ml. were placed in each of 5 tubes containing 10 ml. of medium, 1.0 ml. in each of 5 tubes containing 10 ml. of medium,[f] and 0.1 ml. in each of 5 tubes containing 10 ml. of medium. Tubes were incubated at 25° C. (77° F.) for 72 hours after which they were considered positive if acid, gas, odor, or turbidity were produced. In all cases positive confirmation was made of each tube by subculturing a portion on a solid medium having the same composition as the one just described except for the addition of 1.5% agar. Several attempts were made to use the plate count technique for the egg contents but, owing to the low numbers of organisms encountered, it was considered to be unsatisfactory. Results obtained by this method are reported only where the data are sufficiently complete to warrant statistical treatment. Since the entire egg was used for the counts, all results are expressed as the number of organisms per egg.

RESULTS AND DISCUSSION

Spoilage of dirty commercial eggs. Although many estimates of the percentage of dirty eggs that spoil and become inedible during storage are available, an experiment was carried out to determine this figure for a typical Midwestern produce buyers' eggs. It is not implied that these results are average or even an indication of the normal, but rather that they are typical of central Iowa in the fall months. All of the eggs in this experiment were secured from truck routes making an average of 2 stops per producer per week. The dirty eggs could fairly easily be classified as (a) light manure dirty, (b), "egg contents" dirty, (c), heavy manure dirty, (d) blood dirty, and (e), miscellaneous dirty. It seemed advisable to use such a breakdown for the later experiments since the type and amount of dirt on the shell undoubtedly influence the number and kind of microorganisms present in the egg contents. The eggs were examined at the end of the storage periods (see Table 1) by candling with the usual candling lamp (60 watt frosted bulb in a reflector) and then with an ultra-violet lamp. Following candling, the eggs were broken out and observed under both visible and ultra-violet light for

[f] In some cases an insufficient quantity of egg meat was obtained to fill all of the MPN tubes. In those cases sufficient sterile distilled water was added prior to distribution throughout the tubes to insure the correct amount being available.

TABLE 1

Percent spoilage in stored dirty eggs as measured by several criteria

Kind of eggs	Examination	No. eggs	% Spoilage by					
			Incandescent candle	Ultra-violet candle	Broken out criterion			
					Visible	Odor	Fluorescent[j]	Total
Light dirty	1st[a]	53	5.7		5.7	7.5	5.7	11.3
	2nd[b]	46	6.5		8.7	13.0	10.8	13.0
	3rd[c]	206	2.9	1.9	4.9	4.4	9.2	12.1
"Egg contents" dirty	1st	39	0.0		7.7	10.2	7.7	10.2
	2nd	36	5.5		5.5	2.8	2.8	5.5
	3rd	66	7.7	0.0	7.7	4.6	12.0	12.1
Heavy dirty	1st	35	0.0		5.0	7.5	0.0	7.5
	2nd	35	2.9		5.7	5.7	2.9	5.7
	3rd	72	4.2	0.0	6.9	2.8	5.6	8.3
"Blood" dirty	3rd	19	0.0	0.0	0.0	0.0	5.3	5.3
Misc. dirty	3rd	43	9.3	0.0	9.3	5.0	9.3	11.6

[a] First examination—4 months cold storage, 0.5° C. (33° F.).
[b] Second examination—4 months cold storage plus 10 days at 7-16° C. (45-60° F.) 50% RH.
[c] Third examination—11 months cold storage, 0.5° C. (33° F.).
[j] As determined by spoilage evidence from one or more methods.

appearance and odor. Results of these examinations are given in Table 1. Totals shown in the last column indicate the percentages of inedible eggs without regard to the criterion (odor, appearance, or fluorescence) by which they were so classified. It appears from an examination of these data that nearly all of the spoilage occurring in 11 months took place during the first 4 months of storage. Although the normal candling lamp appears here to be more capable of picking up all types of rots than did the ultra-violet lamp used, the latter was an early model and perhaps ultra-violet lamps in their present improved form might have proved more satisfactory. It must be pointed out that only eggs showing fluorescence will be picked up by the use of ultra violet, regardless of light intensity. A comparatively small number of the organisms known to be responsible for egg spoilage are capable of developing fluorescent pigments. Considerable caution must be exercised in the use of the ultra-violet lamp on this basis and also because of the possible health hazards to those candlers exposed over long periods to the ultra-violet irradiation.

The amount of spoilage observed in this experiment is considerably higher than is usually considered typical in the shell egg industry. Only dirty eggs were stored in this case which accounts for the high results. The spoilage data do point out one of the major difficulties encountered in carrying on a research program on the cleaning of dirty eggs. When only 10-12% of naturally dirtied eggs can be expected to spoil during storage, a large number of eggs must be carried through the experiments if reliable results are to be obtained.

Owing to these considerations, the procedures in this study have been somewhat different from those employed in previous investigations. The bacteriological techniques used have necessitated the employment of smaller numbers of eggs, but it is felt that this can be justified on the basis of the more dependable information obtained regarding the actual microbial contamination. This contamination in most cases was considerably below that level at which contamination would have been observed by the ordinary candling and organoleptic procedures.

Level of initial surface contamination. Since it is logical to assume that the organisms present on the shell surface are potentially those that will contaminate the egg contents (with the exception of those found in the ovaries of diseased birds, i.e. *Salmonella pullorum*), it was considered to be of basic importance to establish an estimate of the number of organisms normally present on the shells of various classes of eggs. Eggs were selected at random from the College Poultry Farm during the period of November through February (1950-1951) and the shell surface counts obtained the day following laying. No attempt was made in these tests to identify the organisms but the flora was noted to be composed primarily of bacteria and not molds. Approximately 15-20% of the eggs were classed as light or heavy dirties with the largest percentage being only stained or slightly soiled. No eggs typical of the "heavy dirts" obtained in the normal trade channels were present in the production sampled. Results of these examinations are shown in Figure 1. Each point in

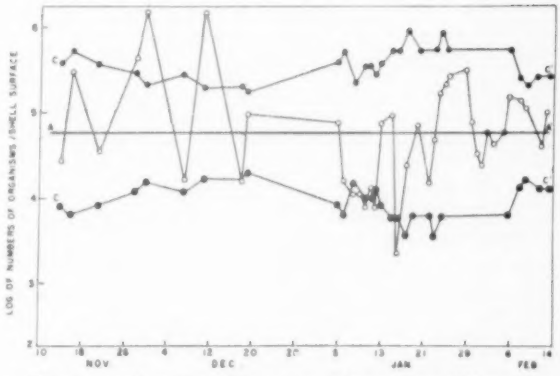

Figure 1. Microorganisms on the shells of eggs laid by hens under identical management conditions.

this figure represents the average count obtained from 4-10 [b] eggs laid the same day. The straight line A-A′ is the overall mean for the entire period. The lines C-C′ are the calculated 3 sigma limits within which 99.73% of the data would be expected, theoretically, to be included and which are commonly used in the control chart for statistical quality control *(4)*. The number of points lying outside these limits give an indication of the extreme variation occasionally encountered. The observed surface contamination of approximately 10,000 to 1,000,000 organisms (a mean value of 63,000, or approximately 1000 organisms per cm. of shell surface) clearly indicates the difficulty of preventing the penetration of organisms even from the shells of eggs much cleaner than those found in the usual marketing channels. The removal of these organisms would be desirable from the public health standpoint regardless of the presence of visible dirt.

Effect of cold storage on bacteria on the surface of eggs. After the initial level of contamination on the shell of the eggs available for experimentation had been established, several experiments were carried out to determine the effect of washing, sweating, and storage on this initial contamination. It has been observed repeatedly that eggs held at high humidities and even at temperatures of 0-2° C. (32-36° F.) are rapidly overgrown with molds and certain species of bacteria *(5)*. There appears to be very little quantitative information regarding changes in the microbiological populations of the surfaces of eggs held at humidities approximating those used in commercial egg handling and storage operations.

If one considers the extreme variations in microbial populations that are ordinarily encountered in sampling shell surfaces of a, clean, b, "egg contents" dirty and c, light manure and litter dirty eggs, it is apparent that the counts reported in Table 2 do not show a definite pattern except for that due to the washing treatment.

It might be assumed in the case of the "egg contents" dirty eggs that considerable growth would occur since dirt is an excellent medium for harboring bacterial growth. That this growth did not occur supports the

[b] This variation in sample size accounts for the irregularity in the Upper and Lower Control Limits of the Control chart.

view that humidities below 80-85% will not provide sufficient moisture for bacterial metabolism.

If storage at 0.5° C. (33° F.) and 86% relative humidity has any appreciable effect on the number of bacteria on the shell surface it would be expected that the reduction of organisms due to washing would be different for washed eggs held for varying lengths of time. When washed and unwashed eggs were held 7 days, the microbial population was reduced 88% by the washing and storage treatment while for eggs held 65 days a reduction of 93% was observed (Table 3). These data were analyzed statistically and no difference was indicated at the 5% level of significance. This is further evidence that these storage conditions do not support microbial growth on the shell surface.

Effect of storage at elevated temperature and humidity on bacterial count on shell surface. An experiment was performed to determine the nature of the changes, if any, occurring at 25° C. (77° F.). Results of this experiment are shown in Figure 2. It appears that a slight decrease in the bacterial population occurs during storage at both 95% and 50% relative humidity. There appeared to be a considerable increase in the counts obtained on the high humidity lots during the course of storage, but this is felt to be due to sweating at the beginning of storage. No mold growth appeared either on the eggs or in the agar plates. However, in previously reported work, molds have been the primary contaminants at the higher humidities. This may be an explanation for the results obtained at the higher humidity.

With the possible exception of a slight decrease in the total number of viable organisms on the shell surface of eggs, it must be concluded that the temperature and humidities used in these experiments result in little change during storage.

Effect of washing on bacteria on shell surfaces. Of primary interest in this study was the effect of washing on the microbial population of the shells of eggs receiving varying handling treatments. It has been suggested that the presence of bacteria and molds on the shell is of considerable importance in itself. Each living organism is a potential spoilage hazard should the opportunity for penetration and growth be presented in any subsequent handling operation. From the public health standpoint any pathogenic organisms on the shell

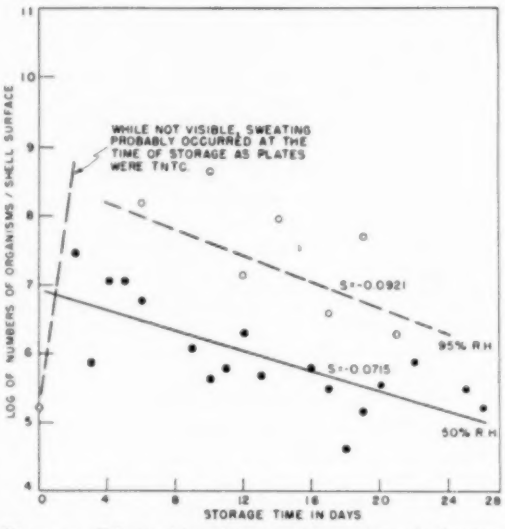
LOG OF NUMBERS OF ORGANISMS / SHELL SURFACE
WHILE NOT VISIBLE, SWEATING PROBABLY OCCURRED AT THE TIME OF STORAGE AS PLATES WERE TNTC.
S=-0.0921
95% R.H.
S=-0.0715
50% R.H.
STORAGE TIME IN DAYS

Figure 2. Effect of humidity on the number of microorganisms on the shell surfaces of unwashed eggs held at 25° C. (77° F.). Each point represents the mean of counts from 4-6 eggs.

surface may be transferred directly to the consumer's hands, or may penetrate the shell as do the spoilage types. From the standpoint of the manufacturer of frozen and dried egg products the inclusion of small particles of shell (with their load of bacteria and molds) in the product during the initial steps of the processing results in "high count" products, which in the extreme case are unacceptable to the consumer. The inclusion of these organisms adds to the already difficult task of pasteurization.

Several experiments were carried out to determine how much reduction in the number of organisms on the shell surfaces could be effected by cleaning with different washing agents. It was necessary to determine the changes on the shells of these washed eggs when held under various storage conditions. In the first of these experiments clean, "egg contents" dirty, and light manure and litter dirty eggs were washed in Vel (0.5%) and Roccal (200 p.p.m.) as described previously. The results obtained are shown in Table 2. There was a considerable reduction of the number of

TABLE 2

Microbiological population changes [1] on the shells of clean, "egg contents" dirty, and light dirty eggs when washed with Vel and Roccal and held in cold storage [m]

Storage period	Condition and washing treatment								
	Clean			Egg contents dirty			Light dirty		
	Control	Roccal	Vel	Control	Roccal	Vel	Control	Roccal	Vel
	Count per shell surface (× 1000)								
Initial	77	71	140	94,000	93,000	93,000	4,500	5,900	5,900
After treatment		0.02	81		200	59		0.54	3.1
1st month	940	4.0	8.4	4,700	49	8.4	9,900	3.3	10
2nd-3rd month	250	52	7.2	11,000	73	5.4	3,400	110	7
4th month	370	3.5	4.7	3,000	69		6,200	13	
5th-6th month	3,000	4.4	26	12,000	1,100	4.1	1,800	5.4	10
Final [n]	1,500	4.6	130	44,000	68	110	800	1,100	72

[l] Standard plate counts—Nutrient agar, incubated at 25° C. (77° F.) for 72 hours.
[m] 0.5° C. (33° F.) 77% relative humidity, constant air circulation.
[n] Final count made eight days after 5th-6th month; eggs held at 13° C. (55° F.), 77% relative humidity during this time.

microorganisms ascribable to the washing treatments. As in the previous experiments there appears to be little if any change in the population during the storage period with possibly an indication of a slight increase in some cases. These results do not differ significantly from those obtained from the stored unwashed eggs. While only average figures are recorded here, it was apparent from an examination of the raw data that Roccal was not as consistent in its microbial reduction as was Vel. This is attributed to the fact that Roccal is not intended to be a cleansing agent and hence was not as effective in removing dirt. Roccal has a considerably higher degree of germicidal activity. This indicates the need of a combined cleansing and germicidal action in the most desirable type of egg washing compound.

During the final elevated-temperature storage which was imposed to approximate the conditions encountered during the wholesaling and retailing of storage eggs, some increases were observed. Of these some were undoubtedly due to moisture condensation although attempts were made to keep sweating at a minimum.

A second series of experiments was planned to duplicate and extend these findings. This series was designed in order to approximate a "split-plot" factorial design. The eggs used were the same as those employed to determine the effect of washing on the interior quality and flavor of shell eggs *(3)*. The data obtained represent the percent microbial reduction due to: a, washing with Vel (0.5%), Roccal (200 p.p.m.), or Kleneg (0.5%), b, to a period of 10 or 30 minutes in the wash water, and c, a holding period of 7 or 65 days. The control eggs were given similar treatments to those given the treated eggs with the exception of washing (or soaking). The results are shown in Table 3. In only two cases was the percent reduction below 80% while the mean of all treatments was 88%. A reduction of this magnitude must be considered as very desirable

TABLE 3

Effect of cleaning and storage treatments [a] on the microbiological populations of shell eggs (surface counts)

Treatment			Counts		Reduction
Washing agent	Soaking period	Storage period	Control	Treated	Percent
	min.	*days*			
Vel	10	7	22,000	7,200	67.2
Vel	30	7	110,000	1,000	98.8
Vel	10	65	170,000	34,000	79.9
Vel	30	65	41,000	4,000	90.1
Roccal	10	7	45,000	2,200	95.0
Roccal	30	7	120,000	2,400	98.0
Roccal	10	65	110,000	11,000	89.8
Roccal	30	65	49,000	7,900	83.9
Kleneg	10	7	170,000	4,800	97.2
Kleneg	30	7	160,000	25,000	84.3
Kleneg	10	65	110,000	8,000	92.7
Kleneg	30	65	67,000	1,300	98.1

	% Reduction
Overall effect of cleansing agent	
Vel	82.2
Roccal	92.8
Kleneg	92.8
Overall effect of soaking time	
10 min.	87.3
30 min.	92.8
Overall effect of storage time	
7 day	88.4
65 day	92.8
Overall total	88.2

[a] Storage conditions 0.5° C. (33° F.) 86% relative humidity, constant air circulation.

provided that no serious penetration of organisms to the interior of the egg results from the washing treatments. Statistical analyses indicated there were no significant differences in the percentage reduction between the washing agents, the soaking periods, or the storage times. Bacteriological examinations of the egg contents were not carried out but each egg was opened, an odor test made and the scrambled egg mixtures subsequently submitted to a taste panel. In no case was there any indication of spoilage.

In spite of the fact that the previous experiments had indicated that little if any growth of microorganisms occurs during storage of unwashed eggs, the possibility that an increase in the number of surface bacteria might occur following the washing treatments was further considered. Eggs were selected, initial counts made, and the eggs divided into two lots. Lot I was washed in Kleneg, according to the procedure previously described, and stored at 25° C. (77° F.), 50% relative humidity. Lot II, the control group, was stored under the same conditions but was not washed. The results of the experiment are shown in Figure 3. The initial reduction due to washing was essentially the same as observed in the earlier experiments. Subsequent changes during the storage period were not significantly different. The benefit resulting from washing, therefore, is not altered during the storage period under these conditions.

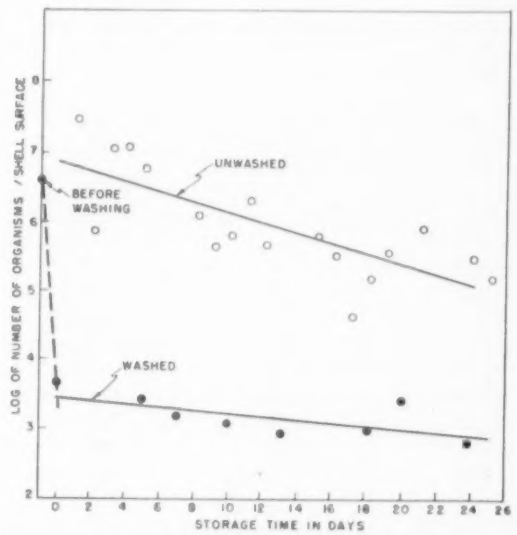

Figure 3. Effect of washing on the numbers of microorganisms during storage at 25° C. (77° F.) and 50% relative humidity.

Level of initial contamination in egg contents. It is generally accepted that the numbers and types of microorganisms in the interior of the egg are of more importance than those found on the shell surface. This was recognized during the course of this investigation and a number of experiments were carried out to determine the incidence (in a small and biased population) and to investigate some factors usually believed to be

responsible for changes in the internal microbial populations of shell eggs.

During this study over 1,000 clean fresh eggs were examined to determine the number of microorganisms present in the egg contents. All of the eggs were examined within 24 hours of laying. The most-probable-numbers counting technique was employed for bacterial counts. As is indicated in (a) of Figure 4, all of the

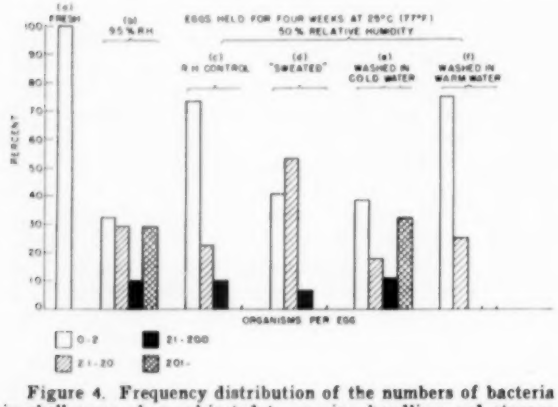

Figure 4. Frequency distribution of the numbers of bacteria in shell eggs when subjected to varying handling and storage treatments.

eggs examined had less than 2 organisms per egg. These results support the statement by Haines *(5)* that "the majority are agreed that the greater proportion of fresh eggs is sterile." The results reported here are considered to be in essential agreement with those data. Wolk, McNally, and Spicknall *(12)* concluded that the percentage of infection in fresh shell eggs is about 12%. As the "percent infected" technique appears to have been more popular than actual counting, no direct comparison can be made with earlier reports. It must be concluded that the initial interior infection of shell eggs can be held at a very low level by proper flock management and egg handling practices. On the basis of these results, subsequent increase in infection and eventual spoilage can be considered due to factors responsible for penetration through the shell.

Effect of washing on microorganisms in egg contents. As was indicated earlier, a major objective of this study was to determine the effects of washing on the penetration of organisms into the egg contents. Since there is ample evidence in the literature and the trade reports regarding the harmful effects of certain poor washing techniques, little effort was made in these experiments to include and compare them with good practice. The method used in this study was designed to embody all of the known desirable points, to be simple and easily controlled, and to duplicate procedures suggested by some manufacturers of egg washing compounds and machines. On a theoretical basis it was predicted that a low level of penetration would occur. All experimental procedures, therefore, were chosen for their efficacy in determining valid bacterial counts when only a few organisms would be present.

The first experiments were designed to compare the microbiological changes in: a, clean, b, "egg contents" dirty, and c, light manure and litter dirty eggs when washed in Roccal or Vel and stored in such manner as to simulate commercial conditions. In these experiments the whites and yolks were separated aseptically and counts made by the MPN technique. In many cases the actual count obtained indicated the presence of less than one organism per egg. This observation emphasizes the need for careful interpretation and evaluation of all data obtained by this technique.

In all cases the albumen initially had counts approximating zero; no change was observed when the eggs were examined 2-4 hours after washing. In several instances eggs had reportable counts during the 5-6 months' cold storage period (0.5° C., 77% relative humidity) but the majority showed no change. In no case was there any indication that the presence of dirt or the washing treatment was responsible for the isolated increases. Following the 5-6 month cold storage period the eggs were given a treatment approximating that to which eggs would be subjected during commercial handling, i.e., 8 days at 13° C. (55° F.), 77% relative humidity. While the data obtained were not sufficient to warrant a rigorous statistical treatment it was conclusive that definite increases resulted from the treatment. Control (unwashed) eggs had counts ranging from 29 (clean) to 262 ("egg contents" dirty) while the washed eggs contained from less than 20 (clean) to 165 ("egg contents" dirty). In all cases the albumen from the washed eggs had fewer bacteria than the unwashed.

Data of a similar nature were obtained upon examination of the yolk of these same eggs. Initial counts and those following the washing treatment approached zero. Similar isolated increases were observed as in the whites. It was considered significant that when albumen was found to contain a higher number of organisms yolk of the same egg was also more heavily contaminated. Bacterial increases resulting from the elevated storage period were also nearly the same as in the albumen. It is concluded that washing these eggs of known history had no appreciable effect on the number of organisms in the egg contents initially or after 5-6 months' cold storage. The washing treatment used here appears to have a slight beneficial effect when cold storage eggs are held at elevated temperatures.

Effect of "sweating" on microorganisms in egg contents. Moran and Piqué *(6)* and Rosser, White, Woodcock and Fletcher *(9)* have reported that sweating results in increases in the spoilage of stored shell eggs. Williams and Ung *(11)* do not concur in these conclusions but believe instead that sweating has little effect on the amount of spoilage. An experiment was designed to test the hypothesis that sweating will increase the number of organisms in eggs. Fresh, clean shell eggs were treated as indicated in Table 4 and held at 25° C. (77° F.), 50% relative humidity, for 6 weeks. At the end of the storage period, the entire contents of 4 eggs were removed—using the previously described aseptic precautions—pooled, and plated on nutrient agar. Sixty-four pooled samples of 4 eggs each were thus examined. The statistical analysis clearly indicates that sweating can be responsible for significant increases in the num-

TABLE 4

Effect of washing and sweating on the microbiological population in held shell eggs[p]

Mean organism count of 16 runs/treatment			
Treatment	Sweated	Unsweated	Average
Washed	124	66	95
Unwashed	219	54	137
Average	172[q]	60	

[p] Eggs held at 25° C. (77° F.) 50% relative humidity for 6 weeks.
[q] Difference is highly significant statistically ($P \leq 0.01$). The standard error of a single determination is 5.9.

ber of organisms present in the egg meat. Although these results show a higher bacteria content in the washed, unsweated than in the unwashed, unsweated eggs, analysis of variance shows this difference not to be significant at the 5% level.

A second experiment was carried out in a similar manner using the most probable numbers technique rather than plate counts. The results of this experiment are given in (c) and (d) of Figure 4. When compared with the control, it is again apparent that sweating results in increased contamination of the egg contents. It is probably more serious when unwashed eggs, with their high surface counts, are allowed to sweat.

Effect of high humidity on microorganisms in egg contents. The effect of high humidity storage on the interior counts is readily apparent from an examination of (b) and (c) in Figure 4. A considerably higher proportion of the eggs held at 95% relative humidity has more than 20 organisms per egg.

No mold growth was visible on these eggs but it might be assumed that molds were present and promoted penetration by other organisms. In the high humidity series considerable mold growth was observed in the MPN tubes.

Effect of improper washing on microorganisms in egg contents. An experiment was carried out in which a washing procedure known to be unsatisfactory was employed. In this case eggs were washed in water 15° C. below the internal temperature of the eggs. Control lots consisting of eggs washed in water at 43° C. (110° F.) and unwashed eggs were placed in the same container and held at 25° C. (77° F.), 50% relative humidity, for four weeks. Counts were obtained by the MPN technique. The results of these observations are presented graphically in (c), (e) and (f) of Figure 4. The greater frequency of high counts in eggs washed in cold water supports evidence indicating that eggs must be washed in water at a temperature higher than the egg. The theoretical basis for this recommendation appears to be well founded.

SUMMARY AND CONCLUSIONS

Owing to the widespread opinion that washing shell eggs is a harmful practice, the results of the experiments reported here must be interpreted with considerable caution. No claim is made that these results are representative of those being obtained at the present time in the egg industry when washed eggs are placed in storage. The experiments completed in this investigation have been carried out in all cases with eggs of known history and were certainly not representative of those eggs found in regular marketing channels. With these facts in mind and on the basis of the data presented, several conclusions may be drawn:

The initial microbial contamination on the shells of clean and light dirty eggs from a flock with good management had a mean value of approximately 63,000 organisms per shell surface, with a range of from about 10,000 to 1,000,000. It may be predicted that commercial eggs will lie in the upper portion of this range or higher.

There is only a slight change in the number of microorganisms on the shells of: a, clean, b, light dirty, and c, heavy dirty eggs when held under conditions usually encountered in commercial handling for periods up to six months.

Washing eggs under the accepted conditions described results in a decrease of 80-90% of the total organisms on the shell surface. This decrease is permanent when the washed eggs are held in storage.

Sweating of shell eggs appears to be responsible for increases in the microbial population of the shell surface.

All of the fresh eggs examined in these experiments had a very low level of contamination. The data indicate counts of 2 or less organisms per egg but the accuracy of the counting technique probably does not justify any conclusion other than that the population is near zero. This substantiates previous reports that most of the freshly laid eggs are sterile on the inside and further indicates that in those "non-sterile" cases the number of organisms is very low.

Eggs properly washed soon after laying had fewer organisms on the inside after storage than did unwashed eggs.

Sweating increases the number of organisms on the inside of both washed and unwashed eggs.

Washing in water colder than the egg results in greater increases in the number of organisms in the egg contents than is observed in clean unwashed eggs, dirty eggs, or eggs washed in the proper manner.

On the basis of the foregoing information, one is led to conclude that from the standpoint of the sanitarian, the egg handler, and the consumer, the cleaning of all eggs, clean or dirty, would be very desirable if properly carried out. The method for washing eggs in this study does not differ significantly from that used by many egg handlers, and it can be satisfactorily controlled. It is of primary importance that the washing be done before any organisms penetrate to the egg contents. It should also be pointed out that any heat treatment which does not provide for a temperature of 60-62° C. (140-144° F.) for at least 2.5-3.0 minutes throughout the entire egg will not effectively kill the organisms present. It is suggested that the main source of trouble in the egg industry, and the primary reason for the considerable variation in the results obtained by different research workers is due to the contamination of the egg contents before the washing treatment is applied.

These conclusions have been drawn solely on the basis of controlled laboratory results and before any washing recommendations could be made to the poultry industry

a comprehensive series of commercial scale experiments, based on these conclusions would need to be carried out. Also the results emphasized the necessity for adequate bacteriological examination in any study to determine the effectiveness of egg cleaning procedures.

Acknowledgments

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What Makes Flavor Leadership?[a]

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There are single products in the food industry which not only lead the field but outsell all others combined. In an attempt to determine the possible role of flavor in this picture, a number of outstanding leaders have been examined in comparison with their nearest competitors. An analysis of several typical situations by the Flavor Profile procedure has been made, which points the way to some interesting observations and conclusions.

Looking broadly at consumer acceptance in foods and beverages, one is impressed by certain products which have an amazing degree of acceptance in their respective classes. It may be argued that this unique position is merely a happy circumstance resulting from excellent advertising, good will, and name. Technical excellence should, of course, be given considerable weight in the analysis of these products, emphasizing uniformity, good quality control, and stability. A few products have been leaders for more than a generation and some may contend that leadership is merely the survival of the fittest; but several of our examples are quite recent in origin *(1)*.

PROCEDURE AND METHOD

As a basis for this study, several brands of 8 different types of foods, confections, and beverages were subjected to careful examination from the standpoint of flavor and quality. It was hoped that this would provide the common denominator of quality for moderately successful products and some clue as to the unique factors of flavor and quality responsible for the outstanding success of certain individual products in each class. The leaders in totally unrelated classes were finally studied with the purpose of discovering any common characteristics. Such a cross comparison is made possible by a study of their Flavor Profiles.

Products examined were catsup, prepared mustard, salad dressing, canned luncheon meat, cola drinks, chocolate bars, peanut butter, and gelatin desserts. These products were chosen because there was a leader in each class which in many areas outsold all others or outsold all others combined. Leaders were chosen on the basis of trade information supplemented by published brand preference studies *(5)*. All brands studied are distributed nationally; therefore, they make no large concessions to regional flavor preferences.

These findings should not be considered academic. Their application may be wide. Food technologists need a flavor standard for their product—whether they use it as a goal for a new product development or as a standard for quality control. Selection of the standard is determined by the type and size of market sought. The products studied for this paper are leaders with wide appeal, and their Profiles indicate what the processor should strive for. If a food company wishes a, to establish a market in a certain region, b, to appeal to a select gourmet group willing to pay well for distinctive flavor, or c, to satisfy a specific national group, he would be wise to investigate the characteristics that appeal peculiarly to the palates of the group he hopes to interest. Yet certain qualities are essential to all successful food products, no matter what their intended market.

Since the products for this study were ones whose preferential position was well established, it was necessary to choose a method of flavor analysis that did not permit the taster's personal preference to enter. The Flavor Profile method *(4)* meets this requisite; furthermore, it permits easy comparison of samples and clear expression of characteristic qualitative and semi-quantitative differences. For the purpose of Profile examination a panel of 6 to 8 trained members is used. The procedure is essentially that presented by the authors before this society in July 1949. It involves, in brief, a tabular record of the intensity

[a] Presented at the Twelfth Annual Meeting of the IFT, Grand Rapids, Michigan, June 11, 1952.

of character notes in the order of their appearance, including taste, aroma, and feeling factors.

According to the Flavor Profile concept, flavor consists of a number of unidentifiable components which combine to produce blend or body and of a few recognizable flavor components or "notes" which give the product character and individuality. The intensity of the character notes can be estimated. The over-all flavor effect contributed by the blend and character notes considered together is termed amplitude, and its intensity can be estimated. A numerical scale is used, ranging from "0" for "not perceptible" to "3" for "strong." Reference standards may be used on critical characteristics.

DISCUSSION

In answer to the question, "What makes flavor leadership?" it may be said firmly, "blended flavor." Blended flavor is not always easy to achieve, but any effort to give a product blended flavor is worth while. Blending shouts "quality." This presupposes that the expected character notes will be in proper register, strongly supported by a body of blended flavor. It does not mean total blandness. No one uses mustard because it is bland, but people prefer a blended mustard. A blended flavor is a smooth flavor, having a good balance of character notes. An unblended or crude flavor may be converted to an interesting blended complex.

Blending flavor can be compared to landscaping a piece of land. The general picture is a mass greenness involving lawn and shrubs. Blended amplitude is provided by the lawn, with shrubs providing interesting character notes. The shrubs may be so placed as to blend with general background of green or they may be put in striking positions where they attract attention and produce a bizarre effect. With flavors, perfect levelness or absence of high notes is not desirable. Many products, such as catsup, have one or two outstanding notes which provide interest, backed by a large volume of blended flavor; whereas some products—for example, milk—are interesting because of the blend and not because of any single note.

It requires experience in developing food products or in developing flavors to achieve a blended flavor; it requires experience in analyzing flavor to determine the proper degree of blending while maintaining interest notes and individuality. Once good flavor is developed, quality control is necessary to insure that all lots maintain the ideal blended flavor.

Although the mechanism by which flavor operates is not understood, we can theorize on its functions. Studies indicate that a good blend requires several compatible elements in the proper proportions, perceived in the proper order, and leaving no aftertaste. That's a compact definition, and it needs amplification.

It is understood that two or more flavor elements are necessary for a blend, for most single flavors are not blended. Flavors occurring in nature are often blends, but man must work to achieve a satisfying blend of flavor in any processed food. This does not mean that a product must have as many ingredients as it does flavor factors. For example, a strawberry is sweet, sour, fruity, and astringent; peanut butter has a number of flavor factors but few ingredients. The complexity of the flavor having several character notes is often a result of the processing. But the variety and character of the notes must be controlled, and supervision of the processing is part of this flavor control. Some products achieve a variety of flavor notes by using a variety of ingredients—for example, cola drinks, catsups, and salad dressing. A complexity of flavor factors makes a food interesting. Of the cola drinks examined in this study, the leader had the most notes and the greatest amplitude of blended flavor; its complexity gave it a distinctiveness that is undoubtedly one of the reasons it is the most popular brand.

But the blending is not accomplished if the ingredients and flavor notes are not compatible. Although vinegar is the principal flavor of one type of candy, who would like vinegar sherbet? Compatibility can be appraised by trained tasters with good judgment. Once a sample is approved by a laboratory panel, food producers submit it to a consumer panel. Compatibility depends somewhat on the preferences and likes of people; sometimes consumers must be educated to new combinations which they might regard as incompatible until recommended. Would you think strawberry ice cream would be good on blueberry pie? The combination was tried by a person who had ordered blueberry pie a la mode; the shop was out of vanilla ice cream, and so he tried the strawberry. He found the flavors compatible. Have you thought of combining rum flavor with chocolate? At least one candy manufacturer has. Trying new combinations requires a person with courage, imagination, experience, and a good taste sense.

The order of appearance of notes is an important aspect of blending, and aftertaste is a consequence of this aspect. The speed with which a note appears depends in part on the nature of the ingredient, in part on the quantity of the stimulus, and also on the use of a blender. Imitation black pepper can often be detected by the speed of the bite; true pepper does not bite till it has been on the tongue for a few seconds. Imitations frequently have a quick bite *(3)*. Red pepper is the ingredient which has a quick bite. Here an ingredient substitution might help in the attainment of a more realistic imitation.

The order of appearance of notes is a basis of difference between products that may make the difference between leading the field or following it. Profiles of catsups presented in an earlier paper *(2)* show that 3 brands exhibited sweetness as the first perceptible note; the fourth had as its first note a baked bean-thiol character. The early appearance of the baked bean note is significant for several reasons. Only one sample had this note, and it was a distinctive characteristic. Its early appearance facilitates identification, for products are identified often by the first recognizable notes.

The first notes appearing to the taster or the consumer make an impression on him. We call that initial impression impact; the flavor analyst evaluates it. He usually has a knowledge of consumer preferences to aid in judging its possible acceptability. The consumer may accept or dislike a product on the basis of the initial impression it makes. While unpleasant characteristics may be an unavoidable part of products, it is preferable that these characteristics should not be the first perceptible notes. Fresh eggs have a naturally occurring sulfide note which, though expected, is not always wel-

corned. The addition of salt and pepper improves the initial flavor impression because the seasonings blend the sulfide note, and thus make it more acceptable.

The wide use of the phrase "to leave a good taste in your mouth" as applied to many situations not pertaining to foods attests to the importance of a good last impression. A good last impression, or controlled aftertaste, is especially important to sales of food products. Aftertaste is caused by the persistence of a single note. In salad dressings the flavor of rancid oil, present in brands other than the leader, is evident in the aftertaste long past the time of the last swallow. Disagreeable aftertastes require something to wash them out of the mouth; it is more difficult to wash them out of the mind. Ill will may be built up and sales hurt by poor aftertaste. Stringent evaluation of ingredients is necessary to avoid the use of flavor degrading materials in processed foods. The leading luncheon meat, salad dressing, and gelatin dessert left no perceptible aftertastes, while the brands following them in preference did leave aftertastes. The second place chocolate suffered from a lasting taste which did not invite further eating. The absence of aftertaste, coupled with a less synthetic type of fruity quality, appeared to be the flavor advantage of the leading gelatin dessert; the second place brand had a synthetic crude fruity aftertaste which lingered for a comparatively long time. The first place cola drink exhibited a quick, clean disappearance of taste which encourages the drinker to take a second sip. If the sips follow one another steadily, more colas are sold. A near competitor to the leading cola drink leaves a persistent flavor note.

An aspect of flavor that contributes to blend or lack of it is the appearance of notes in quick succession. If notes appear in close succession, the over-all flavor seems blended. If some of them appear too slowly, the flavor seems to be out of balance with unintegrated character notes. The leading salad dressing exemplifies integration of notes, with sourness, sweetness, and egginess appearing at the same time.

Lack of integration is partly responsible for 3 factors which have just been discussed: the appearance of a single unacceptable note as the first note, the persistence of a single unacceptable note as aftertaste, and the unblended quality of a flavor throughout its whole life. These considerations all relate to the speed of succession of notes. Each of these problem situations can be alleviated if notes appear and disappear rapidly, for they then seem more nearly blended into one integrated flavor.

A leader often has a mouth-filling flavor. This effect can be described as that produced by a well salted broth. The outstanding salad dressing was mouth-filling, but the other brands examined were mouth-coating. Among the canned luncheon meats this mouth-filling quality was outstanding in the leader.

TABLE 1

Flavor profiles of canned luncheon meats
Flavor-by-mouth

Sample A		Sample B		Sample C	
Amplitude 3		Amplitude 1		Amplitude 1	
Salt	1	Sweet	2	Salt	3
Brothy	3	Salt	3	Denatured meat protein	2
		Denatured meat protein	2	Astringent	1
		Greasy	1	Greasy	1

Key: 1 = Slightly strong; 2 = moderately strong; 3 = strong.

Partial Flavor Profiles of three brands of luncheon meat examined show how the leader relies on good blend and mouth-fullness. According to consumer analyses, Sample A is indicated as the preferred brand, Sample C second, and Sample B follows in third place.

Sample A has a high level of blended flavor, as shown by its amplitude of 3. It has a mouth-filling effect provided by the brothy note; this is supplemented by a low level of saltiness. Sample B has a lower level of total flavor with a prominent denatured meat protein note, similar to a component of corned beef flavor; it is also sweet, salty, and greasy. Sample C has a similar protein note, with saltiness and astringency. But the mouth-filling brothy quality of Sample A seems to be the unique difference between the samples.

SUMMARY

To summarize impressions gained from a study of leaders in 8 different unrelated classes of products, the following attributes are, in part, characteristic of all: early impact of appropriate flavor; pleasant mouth sensation; full body of highly blended flavor; rapid development of full flavor in the mouth; in many cases, a rapid disappearance of flavor on swallowing; and absence of unpleasant notes appearing alone in early impact or in aftertaste.

The true source of these interesting properties is well hidden behind integrated procedures for raw materials procurement, processing, flavoring, and packaging. These qualifications are listed as objectives for future programs on product development and improvement.

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Effect of Growing Area on Tannin and Its Relation to Astringency in Frozen Elberta Peaches

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The tannin content of Elberta peaches from three different growing areas, of varying prevailing climatic conditions, was determined. Differences in relative astringency were directly related to differences in the tannin content of fruit from the various areas.

Astringency is generally associated with the puckering sensation caused by tasting high-tannin-content fruits such as unripe bananas or persimmons. In the immature state these fruits are so astringent that they are considered unpalatable from this standpoint alone. During ripening the astringent properties of these fruits are lost. In studies reported by Loyd in 1911 *(5)*, the disappearance of astringency was not found to be correlated with loss in tannin. This lack of correlation was probably due in part at least to the fact that earlier methods of estimating tannins gave the total amount of tannin-like substances, whereas astringency may result only from certain specific types of tannin compounds.

In 1945 Barnell and Barnell *(2)* developed a method of determining so-called "active" tannins in bananas. The determination is based on the difference in time required for a standard diastase preparation to hydrolyze a given amount of starch in the presence of an aqueous solution of the tannin and in the presence of water. The time required for hydrolysis of the starch is directly related to the amount of tannin in the solution. Using this method they were able to show a gradual loss in tannin during ripening, and the changes were correlated with edible quality.

In peaches some of the greatest differences in astringent properties have been observed among different varieties. Blake and Davidson *(3)* classified a number of different peach varieties according to tannin content and found some of these so high in tannin that they were regarded as relatively unpalatable. They also pointed out the possibility that the same variety grown in certain districts could vary greatly in astringency. In 1942 Blake *(1)* published some additional results of his studies on the acidity and tannin content of peaches. In this latter report he noted that tannin content of certain varieties was affected in varying degrees by the season in which they were grown and he also indicated that climatic factors may have been responsible for the seasonal variations.

Since tannin content is a factor of particular importance in determining the amount of oxidative discoloration that occurs in frozen peaches which have been thawed and exposed to air, work was undertaken in this Laboratory to determine the effect of growing area as influenced by climatic conditions on the amount of tannin produced in the fruit *(4)*. In view of reports to the effect that large amounts of tannin affect the edible quality of fresh peaches, an additional purpose of the project was to investigate the effect of tannin content on the relative astringency of frozen sirup-packed Elberta peaches.

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EXPERIMENTAL

Source of material. The experimental raw material was obtained from 3 different growing areas (designated as A, B, and C) within a relatively small geographical location for 2 consecutive seasons. Each of these areas represents rather definite types of climatic conditions. Area C is generally considered cool, foggy, and cloudy with relatively few bright sunny days, while area A is characterized by very warm and sunny weather. From a climatic standpoint area B is considered intermediate between A and C with respect to temperature and sunshine.

It is recognized that other factors such as soil type, cultural practices, and application of fertilizers may have an effect on the amount of tannin produced in the fruit. However, the peaches from each area were selected from healthy uninjured trees and from orchards which followed as nearly as possible the same general cultural and fertilization practices. Therefore, the main experimental variable is considered to be of climatic origin.

Preparation of materials. The peaches from each of these areas were carefully selected for prime maturity and all were of the Elberta variety. Immediately after harvest, the fruit was transported to the Laboratory by panel truck and processed for freezing preservation. Ripe whole peaches were halved, pitted and steamed (cups down) for 45 seconds followed by fog air cooling. The skins were slipped off. The peeled halves were then sliced (12ths), sorted, and packed directly into No. 2 fruit enamel cans. Sufficient 40° Brix sirup containing 0.1% ascorbic acid was added to completely cover the fruit. The cans were sealed with an automatic sealer, frozen in an air blast at —10° F., and stored at —10° F. (—23.3° C.).

Approximately 25 representative peaches from each lot were selected for analytical determinations. These were frozen whole, slip-peeled by quick immersion in cold water, pitted, quartered, and ground at —10° F. (—23.3° C.) to pass through a 4-mm. screen. The ground material was thoroughly mixed, packed in friction top cans and stored at —10° C. (—23.3° C.) until used for analysis.

ANALYTICAL METHODS

Tannin. Since the tannin-like compounds present in peaches have not as yet been isolated and chemically identified, it is impossible at present to single out any compound or compounds which are responsible for the astringent action found in some peaches. Therefore, the tannin determinations were made on the basis of phenolic compounds, since phenolic groups are considered to be common to all tannins and responsible for their astringent properties. However, it is recognized that peaches may contain simple phenols and other compounds which react with the phenol reagent and should not be classified as tannins. As a matter of fact it has not been established that the more complex phenols from peaches should be classified as such; but since this group of compounds has been commonly referred to as tannins in the past, this terminology will be retained with certain modifications. Total phenolic compounds were determined essentially by the method of Rosenblatt and Peluso *(7)*. The accuracy of this method is ±0.5% over the range of 0.05 to 0.2 milligrams of tannic acid per 100 ml. of solution.

In a previous publication *(4)* it was shown that for most peach varieties the phenolic compounds which are converted to dark brown substances by oxidative enzymes amounted to 70-80% of the total phenols present. A linear relationship was obtained between total phenolic compounds and those which take part in the oxidation, and therefore the oxidizable fraction alone will be considered as tannin, since the other apparent phenolic compounds are not oxidizable. The method of determining the oxidizable fraction is adequately described *(4)* and in essence consists of determining total phenolic compounds prior and subsequent to controlled enzymatic oxidation of the naturally occurring phenolic substances in the peach tissue. The difference between these two values represents the oxidized fraction.

Hereafter, the word tannin will refer to total oxidizable phenols, and tannin difference or difference in tannin value will refer to differences in this fraction between samples from the various areas or seasons.

Total acidity. Total acidity was determined by titrating 100 g. of a uniform mixture containing 100 g. of peaches and 400 g. of distilled water. The sample was titrated with 0.1*N* sodium hydroxide to pH 8.0 with a pH meter and the results are calculated as percent citric acid.

Organoleptic appraisal. All tasting was done on the sliced peaches packed in sirup and ascorbic acid. The samples to be compared on any given day were thawed in cool running water for 4 hours; and after draining, each slice was cut into 4 or 5 pieces so as to provide a more uniform sample for the individual judges. After the slices were prepared for tasting, sirup was added back to the fruit, so that each sample had the same fruit-to-sirup ratio. Triangular taste tests were used to determine organoleptic differences between the samples. A panel of 10 to 15 persons was used and all tasting was done under illumination of sodium vapor lamps which served to eliminate any color differences between samples. Each comparison was repeated 3 to 4 times. The organoleptic results were statistically analyzed for significance by the chi square method of analysis.

RESULTS AND DISCUSSION

Effect of growing area on tannin content. The data in Table 1 show highly significant differences in the tannin content of Elberta peaches from the three areas under study. While the values for the 1949 season are considerably lower than those obtained during 1948, the actual differences between areas are almost the same for the 2 seasons. This would indicate that conditions affecting the accumulation of tannins in this variety of peaches for the 1948 and 1949 seasons were fairly uniform for the 3 areas. The difference in tannin between the 2 years is clearly a seasonal difference which was fairly constant for the 3 areas under consideration. Since the individual areas are all within a radius of not more than 100 miles it is not unlikely that major seasonal climatic changes would affect each area in about the same degree.

TABLE 1
Effect of growing area on the tannin content and total acidity in Elberta peaches

Area	Tannin[b]		Total acidity[c]	
	1948	1949	1948	1949
A	103	69	0.52	0.48
B	151	111	0.43	0.45
C	181	150	0.44	0.46

[b] Expressed as mg. pure tannic acid per 100 g. of peach tissue.
[c] Expressed as percent citric acid.

In this connection Blake *(1)* has reported fluctuations in tannin values due to marked differences in climate from one season to another. In general he found that high tannin values within given varieties were correlated with seasons in which low temperatures and cloudy conditions prevailed during early spring, and that warm, sunny weather during early spring was correlated with low tannin content for the same varieties. These observations on climatic effects are in general agreement with the results obtained from the three areas under investigation.

It has already been pointed out that the main difference between these areas is climatic in nature. The area having the most unfavorable weather from the standpoint of cloudiness and temperature produced peaches which contained the greatest amount of tannin; whereas the lowest tannin values were found in the area having warm to hot sunny weather from spring throughout the summer. The fruit grown in the area which experienced climatic conditions somewhere between the two extremes also had an intermediate tannin value. During the first season, the tannin content of peaches from area B was a little closer to that of fruit from area C, and during the second season it was almost equally spaced between areas A and C.

Since evaluation of climatic conditions in the three areas is qualitative in nature, a definite correlation between tannin value and quantitative figures expressing heat units or number of cloudy days cannot be made at this time. However, differences in temperature and sunlight between these areas are so marked and consistent from season to season that a general correlation based on climatic effects appears to be warranted. It should be noted, however, that these results are based on the Elberta variety only and may not follow the same pattern in all other varieties.

Neither season nor growing area appears to have any significant effect on the total acid content of Elberta peaches used in these experiments. Blake *(1)* also found that the total titratable acidity in the Elberta variety did not vary markedly when grown under different climatic conditions.

Effect of tannin on astringency. During the early part of the organoleptic work, it became evident that there were large differences in sensitivity to astringency among the panel members first selected. Hence it became necessary to screen a large number of persons in order to select a panel who could detect astringent substances. The screening was first done on a synthetic peach juice solution containing varying amounts of reagent-grade tannic acid, and later on peach puree containing varying amounts of the same substance. Members of the panel finally selected were able to detect differences of 15 to 25 mg. of tannic acid per 100 g. of solution or puree with a fair degree of accuracy. Although it is not presumed that the tannins in peaches as measured herein are identical or even similar to reagent-grade tannic acid, the subsequent results show that peach tannins are capable of producing an astringent effect on persons sensitive to these substances.

The data presented in Table 2 show the results obtained on the frozen peaches from the 3 growing areas. Significant differences were observed between areas A and B during both seasons. In 1948, 16 of the 21 judges who correctly identified the duplicates selected the sample having the highest natural tannin

TABLE 2

Comparison of frozen Elberta peaches from different areas with particular emphasis on differences in degree of astringency

Areas under comparison	Number of judges	Number of correct answers	Significance at P = .05	Most astringent sample[4]		Tannin content ratio
				1	2	
A vs. B (1948)	39	21	Yes	5	16	1.47
A vs. B (1949)	24	14	Yes	2	12	1.61
A vs. C (1948)	40	19	Yes	1	18	1.76
A vs. C (1949)	25	19	Yes	1	18	2.17
B vs. C (1948)	27	12	No	6	6	1.20
B vs. C (1949)	32	19	Yes	7	12	1.35

[4] Those of judges who correctly identified duplicates. The figure 1 refers to the area first mentioned in comparison and 2 indicates the area mentioned last.

content as the most astringent, and in 1949, 12 out of 14 correctly selected the higher-tannin samples on the basis of astringency. The differences in tannin value for areas A and B during 1948 and 1949 were 48 and 42 mg./100 g., respectively.

On the basis of results obtained in comparing A and B it would be expected that astringency differences in samples from A and C would be more easily detected because of the higher tannin differences between the latter 2 areas. As expected, significant differences were detected in the samples from these areas, and of those identifying the duplicates, selection of the sample containing the greatest amount of tannin as the most astringent was practically unanimous for both seasons. Obviously, as the tannin difference is increased from 42-48 mg./100 g. to 78-81 mg./100 g., selection of the most astringent sample is definitely facilitated. This also indicates that compared to area A the tannins in the fruit from areas B and C have a definite astringent effect on persons who are sensitive to these substances, and the apparent effect is increased as the difference in tannin content between samples is increased. Although the tannin content in samples from areas B and C was sufficient to cause a definite astringent effect to members of this panel, in our opinion it was not high enough to classify the fruit as unpalatable from the standpoint of astringency. As a matter of fact some of the panel members who readily recognized the differences in astringency preferred the more astringent sample.

Comparison of the fruit from areas B and C showed that the difference between these samples was significant during the 1949 season but not during 1948. For 1948 the tannin contents of areas B and C were 151 and 181 mg./100 g., respectively, giving a difference of only 30 mg. This was the lowest difference encountered between any of the sample pairs tested and existed in the highest range of tannin content.

Although these experiments involved only a small number of samples, it is interesting to note that the results are in accord with the well-known Fechner-Weber principle. This rule states that a difference in sensory response is proportional to S_2/S_1, where S_1 and S_2 are stimuli. Moncrieff *(6)* points out that this relationship holds, within limits, for taste and smell and that with these senses the ratio S_2/S_1 is approximately 1.3 for a barely perceptible difference in sensation. As shown in Table 2, the only comparison in which a detectable difference in astringency was not found is also the only one where the ratio of tannin contents fell below 1.3 (B vs. C, 1948). In 1949 the tannin content ratio between these two areas was 1.35, and the organoleptic results clearly show a significant difference in astringency. Furthermore, as the tannin content ratio increased, a regularly increasing proportion of the judges who correctly identified duplicates were able to identify the more astringent sample. Therefore it appears that for the range of tannin content found in these limited numbers of samples, the taste responses followed the Fechner-Weber relationship.

SUMMARY AND CONCLUSIONS

Frozen Elberta peaches from 3 areas representing different climatic conditions were analyzed for tannin content and subjectively compared for differences in astringency.

In general the area having the warmest and clearest weather produced peaches of the lowest tannin content, while the cooler, cloudy area produced fruit of highest tannin content. The area having climate considered to be intermediate between these two extremes also produced peaches with intermediate tannin contents.

Significant differences in astringency were found in peaches grown in the areas causing the lowest and highest accumulation of tannins. In somewhat lesser degree these differences were also found in fruit from areas of lowest and intermediate tannin content. Differences in astringency between the areas of intermediate and highest tannin content were not detectable during the first season. During the second season a significant difference was detected, but the difference in astringency did not appear to be as marked as in the other comparisons.

The ability to detect differences in astringency due to the tannins found in these peaches appears to depend on the magnitude of the total amount present as well as the magnitude of the difference between samples.

Tannins as determined by the method used herein appear to be correlated fairly well with relative astringency determined by organoleptic means.

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Gelation and Clarification in Concentrated Citrus Juices. III. Effect of Heat Treatment of Valencia Orange and Duncan Grapefruit Juices Prior to Concentration[a,b]

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The effectiveness of heat treatment of citrus juices prior to concentration to prevent gelation and clarification in concentrates is shown to be dependent upon temperature and the quantity of pulp present in the juice. Data are presented showing the effect of heat treatment at various temperatures from 125° to 195° F. (51.5° to 90.5° C.) on the retention of pectinesterase activity in citrus concentrates and the degree of gelation and clarification that occurs during storage of these products at 40° F. (4.5° C.).

Prevention of gelation and clarification in concentrated citrus juices is of major importance to processors, since product quality is affected and economic loss may occur. Rouse *(7)* pointed out that these changes in physical appearance are caused by enzymic action of pectinesterase on the natural pectin present in citrus juices, resulting in the formation of low-methoxyl pectin which then combines with polyvalent ions to form gelatinous pectinates.

The basic factors and those of practical significance, including fruit variety, amount and type of pulp in the concentrated juices, degree of concentration and temperature of storage are described by Wenzel, Moore, Rouse, and Atkins *(9)*. Possible methods for the reduction or prevention of gelation and clarification are modifications of processing procedures or inactivation of the pectic enzymes by heat treatment. Storage at 0° F. (—18.0° C.) at all times also retards these enzymic changes.

By the application of heat to citrus juices before concentration, the reduction or prevention of gelation and clarification in citrus concentrates may be accomplished. The degree of reduction of enzymic action obtained depends upon whether the temperature and time of heating used is sufficient to partially or completely inactivate the pectic enzymes. If inactivation is incomplete, the concentrate should be stored at 0° F. (—18.0° C.), the temperature recommended for storage of frozen concentrated citrus juices. Complete inactivation of the enzymes would permit storage at refrigerated temperatures higher than those possible for the partially inactivated products.

The purpose of this paper is to present information on the effect of heat treatment before concentration of Valencia orange and Duncan grapefruit juices at various pulp levels on a, the retention of pectinesterase activity and b, the degree of gelation and clarification on storage of the concentrates made from heat-treated juices.

EXPERIMENTAL PROCEDURES

Preparation of the juices. The processing procedure for the heat treatment studies is indicated on the flow diagram, Figure 1. The juice, pulp, and seeds were extracted from the fruit using a Citro-Mat extractor and then passed through the Food Machinery finisher with the pressure head set loosely and using a 0.020-inch screen. The juice that passed through the 0.020 inch screen was again screened on a 200-mesh shaker screen. The juice passing through the shaker screen perforations was fed into a Weil turbine pump to size the particles of pulp. The juice, pulp, and seeds extruded from the finisher were again finished with a ⅛-inch screen with the pressure head of the finisher set normally. The juice and pulp that passed through the ⅛-inch screen were also sized in the Weil turbine pump. Finally both juices containing sized pulp particles were blended together to make single-strength juice with 5, 10, or 15% pulp content by volume.

Heat treatment and concentration of the juices. The juices were pumped through 40 feet of 3/16-inch I.D. stainless steel heating tube at a flow rate of one gallon per minute. Hot water was circulated around the heating tube to provide the desired temperatures that ranged from 125° to 195° F. (51.5° to 90.5° C.). The time required to heat the juices from room temperature to the desired temperature was 3 seconds. The juices were discharged directly from the heater into the evaporator, thereby immediately lowering the temperature of the juice to 70° F. (21.0° C.). After concentration of the juice to 42° Brix, the concentrate was filled into 6-ounce cans, vacuum sealed, and placed in —8° F. (—22.0° C.) storage. No freshly extracted cut-back juice was used in any of the concentrates. Figure 2 shows the small pilot plant evaporator used in these studies. A description of it has been published *(1)*.

Analyses of the juices and concentrates. The juices prior to heat treatment were examined for pulp content by a centrifugal method *(8)*. Samples for pectinesterase determinations were prepared from 42° Brix concentrates by weighing 25 g. of the concentrates into 100 ml. tared volumetric flasks. These were made to volume with distilled water. The method for measurement of pectinesterase activity included parts of the procedures by both MacDonnell, Jansen, and Lineweaver *(3)* and McColloch and Kertesz *(4)* as modified by Rouse and Atkins *(6)*. The pectinesterase units are expressed by the symbol (PE.u.) ml./° Brix which represents the milliequivalents of ester hydrolyzed per minute per milliliter per ° Brix. The ° Brix of the juices was determined at 82.4° F. (28.0° C.) using a Bausch and Lomb Abbe type refractometer. Gelation and clarification in the concentrates were determined by previously described methods *(2, 5)*. The concentrates were removed from —8° F. (—22.0° C.) storage and placed immediately into 80° F. (26.5° C.) storage for examination after 24 hours and also into 40° F. (4.5° C.) storage for examination after 1 and 2 weeks, and 1, 2, and 3 months. Degree of gelation is indicated as none, very slight, slight, semi-gel, or solid gel. The occurrence of a semi-gel or solid gel in a frozen citrus concentrate would cause consumer complaints.

[a] Presented at the Twelfth Annual Meeting of the IFT, Grand Rapids, Michigan, June 9, 1952.

[b] Cooperative research project of Florida Citrus Commission and Florida Citrus Experiment Station, Lake Alfred, Florida, aided by a grant from the American Can Company. Florida Agricultural Experiment Station Journal Series, No. 85.

[c] Florida Citrus Commission.

[d] Florida Citrus Experiment Station.

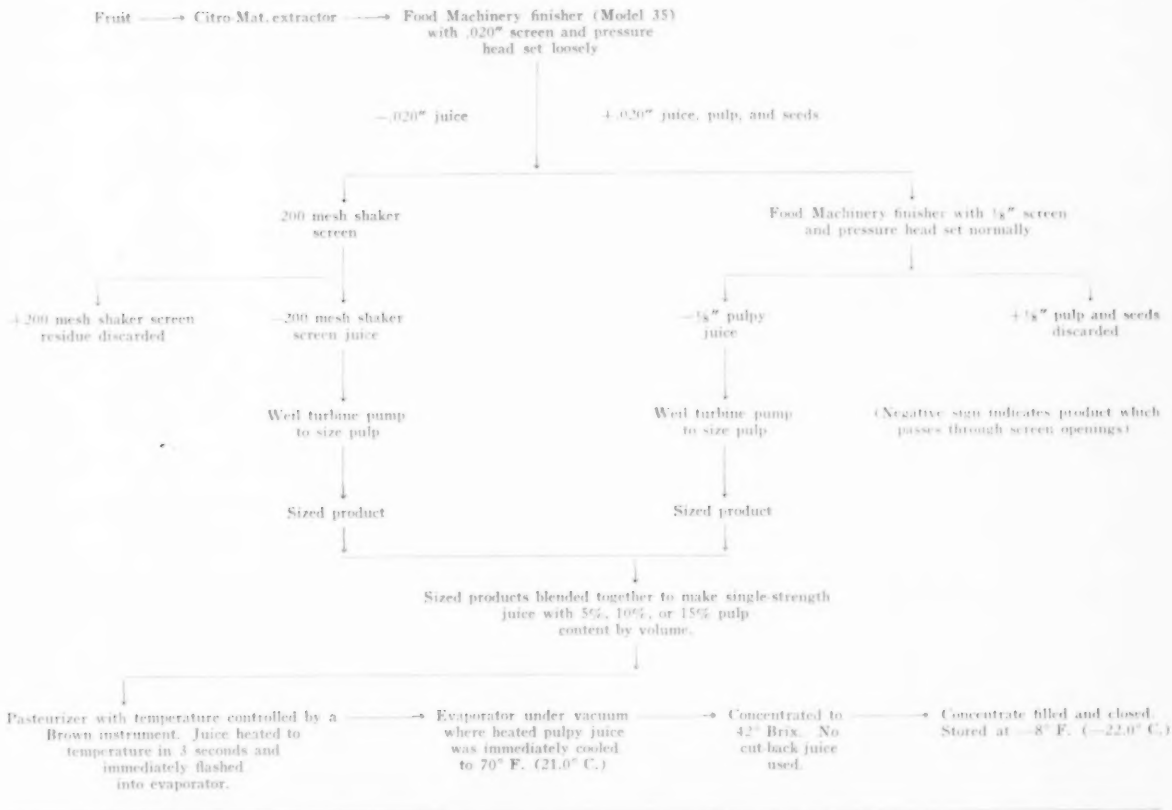
Fruit
Citro-Mat extractor
Food Machinery finisher (Model 35) with .020" screen and pressure head set loosely
−.020" juice
+.020" juice, pulp, and seeds
200 mesh shaker screen
Food Machinery finisher with ⅛" screen and pressure head set normally
+200 mesh shaker screen residue discarded
−200 mesh shaker screen juice
−⅛" pulpy juice
+⅛" pulp and seeds discarded
Weil turbine pump to size pulp
Weil turbine pump to size pulp
(Negative sign indicates product which passes through screen openings)
Sized product
Sized product
Sized products blended together to make single-strength juice with 5%, 10%, or 15% pulp content by volume.
Pasteurizer with temperature controlled by a Brown instrument. Juice heated to temperature in 3 seconds and immediately flashed into evaporator.
Evaporator under vacuum where heated pulpy juice was immediately cooled to 70° F. (21.0° C.)
Concentrated to 42° Brix. No cut-back juice used.
Concentrate filled and closed. Stored at −8° F. (−22.0° C.)

Figure 1. Processing procedure for heat treatment studies on Valencia orange and Duncan grapefruit juices.

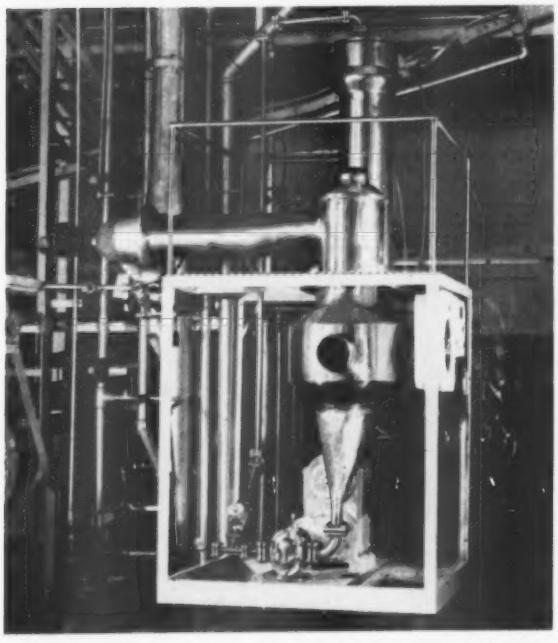

Figure 2. Small, low-temperature, high-vacuum, pilot plant evaporator used for preparation of citrus concentrates.

The clarification or loss of "cloud" in the concentrates was determined by measuring the percentage of light transmission through a sample of the reconstituted juice after centrifuging for 15 minutes at 1700 r.p.m. in an International Centrifuge, Size 1, Type SB. A Lumetron colorimeter, Model No. 402-E, with a No. 730 filter and 10 mm. rectangular absorption cell calibrated to read 100 with distilled water was used to measure the percentage of light transmission. The concentrates were reconstituted with 3 volumes of deionized water immediately after removal from storage. The degree of clarification in the centrifuged orange juices is indicated by the percentage light transmission as follows: 0-59% = none; 60-69% = slight; 70-84% = definite; 85-100% = extreme. The degree of clarification in the centrifuged grapefruit juices is indicated by the percentage light transmission as follows: 0-69% = none; 70-79% = slight; 80-89% = definite; 90-100% = extreme. Definite clarification would be noticeable to the consumer and extreme clarification would cause consumer complaints.

EXPERIMENTAL RESULTS AND DISCUSSION

The effect of various heat treatments of Valencia orange juice prior to concentration on the pectinesterase activities of the resulting 42° Brix concentrates is shown in Table 1. As expected, pectinesterase activities in the concentrates were found to decrease as the temperature of heat treatment was increased, but the amount of enzyme activity was always highest in concentrate prepared from the juice containing the highest pulp content. For example, after heating the 5, 10, and 15% pulpy juices to a temperature of 145° F.

TABLE 1

Effect of heat treatment of Valencia orange juice before concentration on pectinesterase activity and short-term elevated storage temperature on gelation and clarification in 42° Brix concentrates

Thermal treatment		Percent pulp by volume								
		5	10	15	5	10	15	5	10	15
		(PE.u.) ml./° Brix × 1000			Degree of gelation after 24 hr. at 80° F. (26.5° C.)			Degree of clarification after 24 hr. at 80° F. (26.5° C.)		
°F.	°C.									
Control	(not heated)	17.7	31.4	50.1	None	Semi-gel	Solid gel	Extreme	Extreme	Extreme
135	57.0	16.8	31.8	51.8	None	Semi-gel	Solid gel	Extreme	Extreme	Extreme
145	63.0	11.7	24.3	40.3	None	Semi-gel	Solid gel	Extreme	Extreme	Extreme
155	68.5	11.5	19.6	32.3	None	Slight	Semi-gel	None	Extreme	Extreme
165	74.0	8.6	11.6	17.0	None	None	Slight	None	None	None
175	79.5	3.3	5.8	8.0	None	None	None	None	None	None
185	85.0	1.1	1.5	2.4	None	None	None	None	None	None
195	90.5	0.3	0.9	1.5	None	None	None	None	None	None

(63.0° C.) the resulting concentrates contained pectinesterase activities of 11.7, 24.3, and 40.3, respectively.

Also presented in Table 1 is the effect of heat treatment of Valencia orange juice on gelation and clarification in 42° Brix concentrates after 24 hours storage at 80° F. (26.5° C.). This is a short term high temperature storage by which gelation and clarification in citrus concentrates may be determined and gelation of the Valencia orange concentrate is shown in Figure 3. No gelation occurred in the concentrates made from 5% pulpy juices while extreme clarification appeared in the 5% pulpy concentrates only for the control through the 145° F. (63.0° C.) samples.

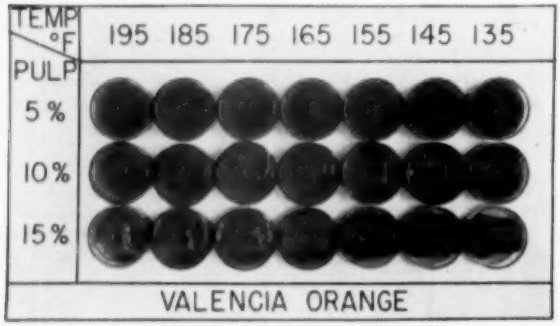

Figure 3. Gelation in Valencia orange concentrate after storage for 24 hours at 80° F. (26.5° C.).

Gelation and clarification in frozen Valencia orange concentrates when placed in 40° F. (4.5° C.) storage for 1 and 2 weeks and 1, 2, and 3 months are indicated in Tables 2 and 3. After one week storage of the concentrates the 5% pulp level showed very slight gelation and extreme to definite clarification in the control through the 145° F. (63.0° C.) samples. After 3 months storage gelation was found to vary from very slight to solid gels in the concentrates and clarification to vary from none to extreme as indicated in Tables 2 and 3. Traces of activity remaining in the Valencia orange concentrates caused the occurrence of gelation when the products were stored at 40° F. (4.5° C.) that was not in evidence at the end of 24 hours storage at 80° F. (26.5° C.); however, clarification did not occur in samples heated to 195° F. (90.5° C.), regardless of which storage test was used.

Data on changes in pectinesterase activity, gelation, and clarification in Duncan grapefruit concentrates brought about by the application of heat to juices before concentration to 42° Brix are given in Tables 4, 5, and 6. The degree of gelation in this series of concentrates after 24 hours storage at 80° F. (26.5° C.) is shown in Figure 4. Concentrates made from grapefruit juice had less enzyme activity in the control than Valencia orange concentrates containing the same quantity of pulp. The most activity in grapefruit juice, as was found in orange juice after heating to any specific temperature, was

TABLE 2

Effect of heat treatment on the degree of gelation in Valencia orange concentrates stored at 40° F. (4.5° C.)

Pulp content	Length of storage at 40° F. (4.5° C.)	Heat treatment prior to concentration to 42° Brix							
		195° F. (90.5° C.)	185° F. (85.0° C.)	175° F. (79.5° C.)	165° F. (74.0° C.)	155° F. (68.5° C.)	145° F. (63.0° C.)	135° F. (57.0° C.)	Control (not heated)
5%	Initial	None	None	None	None	None	None	None	None
	1 wk.	None	None	None	None	None	Very slight	Very slight	Very slight
	2 wk.	None	None	Very slight	Very slight	Very slight	Very slight	Slight	Slight
	1 mo.	Very slight	Very slight	Very slight	Very slight	Very slight	Very slight	Slight	Slight
	2 mo.	Very slight	Very slight	Very slight	Very slight	Very slight	Very slight	Slight	Slight
	3 mo.	Very slight	Very slight	Very slight	Very slight	Very slight	.....	.....	.....
10%	Initial	None	None	None	None	None	None	None	Very slight
	1 wk.	Very slight	Very slight	Very slight	None	Very slight	Semi-gel	Solid gel	Solid gel
	2 wk.	Very slight	Very slight	Very slight	Very slight	Semi-gel	Semi-gel	Solid gel	Solid gel
	1 mo.	Slight	Slight	Slight	Semi-gel	Semi-gel	Solid gel	Solid gel	Solid gel
	2 mo.	Slight	Slight	Semi-gel	Semi-gel	Semi-gel	Semi-gel	Solid gel	Solid gel
	3 mo.	Slight	Semi-gel	Semi-gel	Semi-gel	Semi-gel	.....	.....	.....
15%	Initial	None	None	None	None	None	Very slight	Very slight	Slight
	1 wk.	Very slight	Very slight	Very slight	None	Semi-gel	Solid gel	Solid gel	Solid gel
	2 wk.	Slight	Slight	Very slight	Slight	Solid gel	Solid gel	Solid gel	Solid gel
	1 mo.	Slight	Slight	Slight	Semi-gel	Solid gel	Solid gel	Solid gel	Solid gel
	2 mo.	Semi-gel	Semi-gel	Semi-gel	Semi-gel	Solid gel	Solid gel	Solid gel	Solid gel
	3 mo.	Semi-gel	Semi-gel	Solid gel	Solid gel	Solid gel	.....	.....	.....

TABLE 3

Effect of heat treatment on the degree of clarification in Valencia orange concentrates stored at 40° F. (4.5° C.)

Pulp content	Length of storage at 40° F. (4.5° C.)	Heat treatment prior to concentration to 42° Brix							
		195° F. (90.5° C.)	185° F. (85.0° C.)	175° F. (79.5° C.)	165° F. (74.0° C.)	155° F. (68.5° C.)	145° F. (63.0° C.)	135° F. (57.0° C.)	Control (not heated)
5%	Initial	None	None	None	None	None	None	None	None
	1 wk.	None	None	None	None	None	Definite	Extreme	Extreme
	2 wk.	None	None	None	None	None	Extreme	Extreme	Extreme
	1 mo.	None	None	None	Slight	Extreme	Extreme	Extreme	Extreme
	2 mo.	None	None	Definite	Extreme	Extreme	Extreme	Extreme	Extreme
	3 mo.	None	Extreme	Extreme	Extreme	Extreme	—	—	—
10%	Initial	None	None	None	None	None	None	None	None
	1 wk.	None	None	None	None	None	Extreme	Extreme	Extreme
	2 wk.	None	None	None	None	Definite	Extreme	Extreme	Extreme
	1 mo.	None	None	None	Definite	Extreme	Extreme	Extreme	Extreme
	2 mo.	None	Slight	Extreme	Extreme	Extreme	Extreme	Extreme	Extreme
	3 mo.	None	Extreme	Extreme	Extreme	Extreme	—	—	—
15%	Initial	None	None	None	None	None	None	None	Slight
	1 wk.	None	None	None	None	Definite	Extreme	Extreme	Extreme
	2 wk.	None	None	None	None	Extreme	Extreme	Extreme	Extreme
	1 mo.	None	None	None	Definite	Extreme	Extreme	Extreme	Extreme
	2 mo.	None	Slight	Extreme	Extreme	Extreme	Extreme	Extreme	Extreme
	3 mo.	None	Extreme	Extreme	Extreme	Extreme	—	—	—

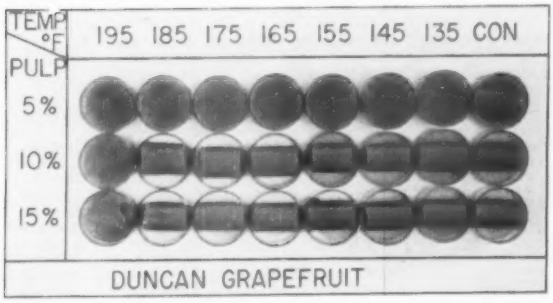

Figure 4. Gelation in Duncan grapefruit concentrates after storage for 24 hours at 80° F. (26.5° C.).

associated with the highest pulp content. When the 27 grapefruit concentrates were stored at 80° F. (26.5° C.) for 24 hours, definite or extreme clarification was found in all samples except 3. The 5 and 10% pulp level samples, in which instance heat treatment of 195° F. (90.5° C.) was used, were the only 2 that did not clarify. Gelation also occurred in most of these samples; however, with 5% pulpy juices no gelation was evident where application of heat at 155° F. (68.5° C.) or above was used. At the 10 and 15% pulp levels solid gels formed in all samples except where a temperature of 195° F. (90.5° C.) was applied.

When the Duncan grapefruit concentrates were stored at 40° F. (4.5° C.) for periods varying from one week to 3 months, results definitely illustrate that complete inactivation of pectinesterase is necessary if gelation and clarification are to be prevented in citrus concentrates that are not to be frozen, but stored at refrigerated temperatures. Data presented in Tables 5 and 6 show that definite or extreme degrees of clarification and gelation were evident in most of the 135 samples of grapefruit concentrates examined after storage at 40° F. (4.5° C.). After one month of storage semi-gels or solid gels were found in all samples except one, which was made from 5% pulpy juice that was heated to 195° F. (90.5° C.). Only 2 out of 27 of the grapefruit concentrates showed no clarification after storage for one month and these also had been heated to 195° F. (90.5° C.). After storage for 3 months there was only one sample, which was made from 5% pulpy juice heated before concentration to 195° F. (90.5° C.), that did not show extreme clarification or set to either a semi-gel or a solid gel. Gelation and clarification were much more pronounced in the grapefruit concentrates than in those made from Valencia orange juice, when the same pulp levels and heating temperatures were used.

SUMMARY

Valencia orange and Duncan grapefruit juices of 5, 10, or 15% pulp content were initially heated at various temperatures from 125° to 195° F. (51.5° to 90.5° C.) and then concentrated to 42° Brix. The concentrates

TABLE 4

Effect of heat treatment of Duncan grapefruit juice before concentration on pectinesterase activity and short-term elevated storage temperature on gelation and clarification in 42° Brix concentrates

Thermal treatment		Percent pulp by volume								
		5	10	15	5	10	15	5	10	15
		(PE u.) ml./° Brix × 1000			Degree of gelation after 24 hr. at 80° F. (26.5° C.)			Degree of clarification after 24 hr. at 80° F. (26.5° C.)		
°F.	°C.									
Control	(not heated)	14.0	29.2	38.0	Semi-gel	Solid gel	Solid gel	Extreme	Extreme	Extreme
125	51.5	13.0	27.4	38.3	Semi-gel	Solid gel	Solid gel	Extreme	Extreme	Extreme
135	57.0	11.7	24.2	28.6	Very slight	Solid gel	Solid gel	Extreme	Extreme	Extreme
145	63.0	6.6	11.2	16.5	Very slight	Solid gel	Solid gel	Extreme	Extreme	Extreme
155	68.5	2.9	4.7	5.6	None	Solid gel	Solid gel	Definite	Extreme	Extreme
165	74.0	2.3	3.9	5.2	None	Solid gel	Solid gel	Slight	Extreme	Extreme
175	79.5	1.7	2.9	4.2	None	Solid gel	Solid gel	Definite	Extreme	Extreme
185	85.0	1.2	2.9	3.4	None	Solid gel	Solid gel	Definite	Extreme	Extreme
195	90.5	0.6	0.9	1.7	None	None	Slight	None	None	Definite

TABLE 5

Effect of heat treatment on the degree of gelation in Duncan grapefruit concentrates stored at 40° F. (4.5° C.)

Pulp content	Length of storage at 40° F. (4.5° C.)	Heat treatment prior to concentration to 42° Brix								
		195° F. (90.5° C.)	185° F. (85.0° C.)	175° F. (79.5° C.)	165° F. (74.0° C.)	155° F. (68.5° C.)	145° F. (63.0° C.)	135° F. (57.0° C.)	125° F. (51.5° C.)	Control (not heated)
5%	Initial	None	None	None	None	None	None	None	None	None
	1 wk.	None	None	None	None	None	None	Slight	Slight	Solid gel
	2 wk.	None	Very slight	Very slight	Very slight	Very slight	Very slight	Semi-gel	Solid gel	Solid gel
	1 mo.	Very slight	Semi-gel	Semi-gel	Slight	Slight	Semi-gel	Solid gel	Solid gel	Solid gel
	2 mo.	Very slight	Semi-gel	Semi-gel	Slight	Semi-gel	Semi-gel	Solid gel	Solid gel	Solid gel
	3 mo.	Very slight	Semi-gel	Semi-gel	Semi-gel	Semi-gel	Semi-gel	Solid gel	Solid gel	Solid gel
10%	Initial	None	None	None	None	None	None	None	None	None
	1 wk.	None	Semi-gel	Solid gel	Semi-gel	Slight	Solid gel	Solid gel	Solid gel	Solid gel
	2 wk.	None	Solid gel	Solid gel	Solid gel	Solid gel	Solid gel	Solid gel	Solid gel	Solid gel
	1 mo.	Semi-gel	Solid gel	Solid gel	Solid gel	Solid gel	Solid gel	Solid gel	Solid gel	Solid gel
	2 mo.	Solid gel	Solid gel	Solid gel	Solid gel	Solid gel	Solid gel	Solid gel	Solid gel	Solid gel
	3 mo.	Solid gel	Solid gel	Solid gel	Solid gel	Solid gel	Solid gel	Solid gel	Solid gel	Solid gel
15%	Initial	None	None	None	None	None	Slight	Slight	Solid gel	Solid gel
	1 wk.	None	Solid gel	Solid gel	Solid gel	Solid gel	Solid gel	Solid gel	Solid gel	Solid gel
	2 wk.	Very slight	Solid gel	Solid gel	Solid gel	Solid gel	Solid gel	Solid gel	Solid gel	Solid gel
	1 mo.	Solid gel	Solid gel	Solid gel	Solid gel	Solid gel	Solid gel	Solid gel	Solid gel	Solid gel
	2 mo.	Solid gel	Solid gel	Solid gel	Solid gel	Solid gel	Solid gel	Solid gel	Solid gel	Solid gel
	3 mo.	Solid gel	Solid gel	Solid gel	Solid gel	Solid gel	Solid gel	Solid gel	Solid gel	Solid gel

TABLE 6

Effect of heat treatment on the degree of clarification in Duncan grapefruit concentrates stored at 40° F. (4.5° C.)

Pulp content	Length of storage at 40° F. (4.5° C.)	Heat treatment prior to concentration to 42° Brix								
		195° F. (90.5° C.)	185° F. (85.0° C.)	175° F. (79.5° C.)	165° F. (74.0° C.)	155° F. (68.5° C.)	145° F. (63.0° C.)	135° F. (57.0° C.)	125° F. (51.5° C.)	Control (not heated)
5%	Initial	None	None	None	None	None	None	None	None	Definite
	1 wk.	None	None	None	None	None	Slight	Extreme	Definite	Extreme
	2 wk.	None	Definite	Definite	Slight	Slight	Definite	Extreme	Extreme	Extreme
	1 mo.	None	Extreme	Extreme	Extreme	Definite	Extreme	Extreme	Extreme	Extreme
	2 mo.	None	Extreme	Extreme	Extreme	Extreme	Extreme	Extreme	Extreme	Extreme
	3 mo.	None	Extreme	Extreme	Extreme	Definite	Extreme	Extreme	Extreme	Extreme
10%	Initial	None	None	None	None	None	None	None	Definite	Extreme
	1 wk.	None	Extreme	Definite	Definite	Slight	Definite	Extreme	Extreme	Extreme
	2 wk.	None	Extreme	Extreme	Extreme	Extreme	Extreme	Extreme	Extreme	Extreme
	1 mo.	None	Extreme	Extreme	Extreme	Extreme	Extreme	Extreme	Extreme	Extreme
	2 mo.	Extreme	Extreme	Extreme	Extreme	Extreme	Extreme	Extreme	Extreme	Extreme
	3 mo.	Extreme	Extreme	Extreme	Extreme	Extreme	Extreme	Extreme	Extreme	Extreme
15%	Initial	None	None	None	None	None	None	None	Definite	Definite
	1 wk.	None	Extreme	Extreme	Definite	Definite	Extreme	Extreme	Extreme	Extreme
	2 wk.	None	Extreme	Extreme	Extreme	Extreme	Extreme	Extreme	Extreme	Extreme
	1 mo.	Extreme	Extreme	Extreme	Extreme	Extreme	Extreme	Extreme	Extreme	Extreme
	2 mo.	Extreme	Extreme	Extreme	Extreme	Extreme	Extreme	Extreme	Extreme	Extreme
	3 mo.	Extreme	Extreme	Extreme	Extreme	Extreme	Extreme	Extreme	Extreme	Extreme

were placed at —8° F. (—22.0° C.) until frozen, then samples were removed and stored at both 80° F. (26.5° C.) for 24 hours and at 40° F. (4.5° C.) for 3 months. Samples were examined for pectinesterase activity, gelation, and clarification.

The effectiveness of heat treatment of the juices prior to concentration to prevent gelation and clarification in the concentrates was found to be dependent upon temperature and quantity of pulp present in the juices. Degree of gelation and clarification that occurred in both orange and grapefruit concentrates was primarily dependent upon the amount of pectinesterase still active in the heated juices; however, gelation and clarification were greater in Duncan grapefruit concentrates than in concentrates made from Valencia oranges. Traces of pectinesterase present in concentrates prepared from heat-treated juices eventually caused marked gelation and clarification when the concentrates were stored at 40° F. (4.5° C.).

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Efficacy of Added Ascorbic Acid in the Control of Discoloration of Kraut

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(Manuscript received August 12, 1952)

Darkening of color of kraut has been shown to be essentially an oxidative process *(16)*. It was observed to follow oxidation of the ascorbic acid occurring naturally in the kraut. It is affected by the amount of available oxygen present. Added ascorbic acid has some effect in inhibiting color changes in canned sauerkraut *(14)*. Preliminary work indicated that levels of 200-250 mg./lb. of ascorbic acid added to kraut in pliofilm bags enabled it to be stored at refrigerator temperature 30 days with excellent color protection *(2)*.

The destructive effect of metallic ions such as copper on ascorbic acid in various foods is reflected in loss of flavor and color values *(8, 16, 18)*. In solutions of ascorbic acid copper was found very effective in catalyzing its oxidation *(3, 4, 6, 9)*. Cupric contamination of kraut similarly was shown to catalyse the oxidation of the ascorbic acid and darkening of color even at a relatively low oxygen level. Presence of greater oxygen levels was shown necessary for comparable effects by contaminant iron on kraut. The exposure of sauerkraut to fluorescent light increases significantly the rate of oxidation of ascorbic acid, as well as darkening of color and the development of undesirable flavor and odor even in the absence of air *(16)*.

The present study was made to determine the possible advantage in the use of added ascorbic acid for the control of undesirable changes in color and flavor of sauerkraut packed in pliofilm bags and stored under refrigeration.

PROCEDURE

The manner of processing, treatment, storage and examination of the samples of kraut was essentially that as previously described *(1, 16)*. Solutions of pure ascorbic acid, ferric chloride and cupric chloride were added to the kraut in the 120-gauge pliofilm bags. All bags were sealed without vacuum treatment. One set of samples was stored in the dark, and another was uniformly exposed at a distance of 24 inches to light from 40-watt soft white fluorescent lamps.

The change in color of the kraut was determined by the Hunter Color Difference Meter standardized with National Bureau of Standards plate No. 57-373-383 and S.K.C.S.B.S. (Ivory 31) following the same procedure applied in previous work *(16)*. Though satisfactory for use on kraut, the Hunter Color Difference Meter was unsatisfactory for measuring the relative rate of darkening of kraut juice because of varying degrees of turbidity.

The method of determining non-enzymatic browning of dehydrated vegetables by measuring optical density was employed to evaluate color changes in the centrifuged juice *(7, 13)*. The juice was centrifuged 2 times at 5000 r.p.m. for 5 minutes and filtered 2 successive times. Its optical density was measured using a Beckman spectrophotometer with a slit width of 0.3 and a wave length emission of 400 mμ.

Examination of samples for flavor, color and ascorbic acid content was made at weekly intervals. Flavor examination was made by a panel from the department staff. Evaluation of flavor was determined on a placement rating basis. Approximately 10 ml. of the juice taken from the samples at different intervals was used for the determination of the ascorbic acid by the A.O.A.C. method. Corrections were made for metallic effect by using hydrogen peroxide and the necessary blanks. Portions also were taken from each bag, transferred to and frozen in pyrex tubes for further examination. The effect of additions of ascorbic acid was calculated by determining the percent ascorbic acid oxidized at each interval and plotting the results to illustrate the rates of oxidation. The change in a_L values at different intervals was similarly plotted to indicate the rates of darkening.

RESULTS

Samples Stored at 45° F. (7.2° C.) in the Dark

Effect of added ascorbic acid. The rate of oxidation of ascorbic acid, and of darkening of kraut to which levels of 0, 100 and 200 mg./lb. of the acid were added is shown in Figures 1 and 2. The addition of ascorbic

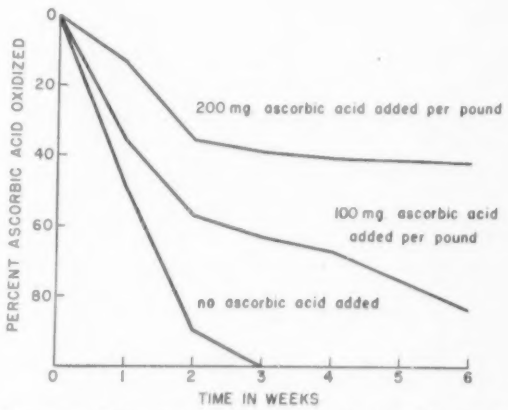

Figure 1. Rate at which ascorbic acid is oxidized when added at different levels to kraut stored at 45° F. in the dark.

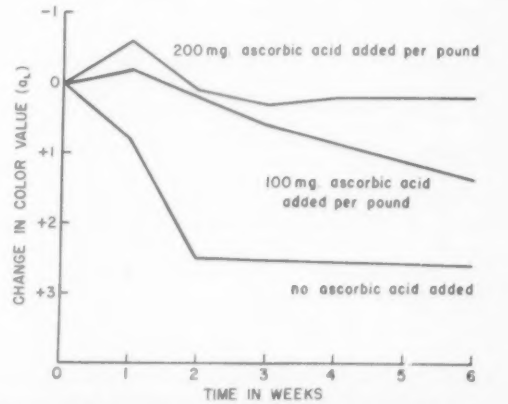

Figure 2. Effect of varied levels of added ascorbic acid on the rate of discoloration of kraut stored at 45° F. in the dark. (Measured as change in a_L value.)

acid was found beneficial in controlling darkening of the kraut stored in the dark. It was found also to enhance a pleasant flavor. The use of the greater levels of added ascorbic acid was found advantageous when the storage period was greater than 4 weeks. The color values remained within an acceptable range for over 6 weeks when 200 mg./lb. ascorbic acid was added *(16)*. The added acid appeared to affect both hue, and brightness (a_L and L values) as measured by the Hunter Color Difference Meter.

Effect of metallic contamination. The relative rates of oxidation and of darkening of color of kraut to which has been added ascorbic acid, and cupric (3 p.p.m.) and ferric (10 p.p.m.) ions respectively, is shown in Figures 3 and 4. Added ascorbic acid has a marked protective

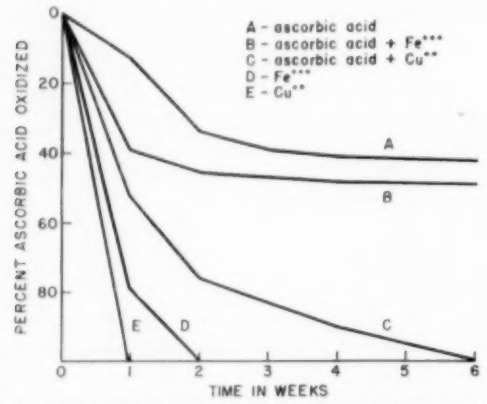

Figure 3. Relative rates of oxidation of ascorbic acid in kraut (200 mg./lb. added) to which has been added ferric (10 ppm.) and cupric (3 ppm.) ions and stored at 45° F. in the dark.

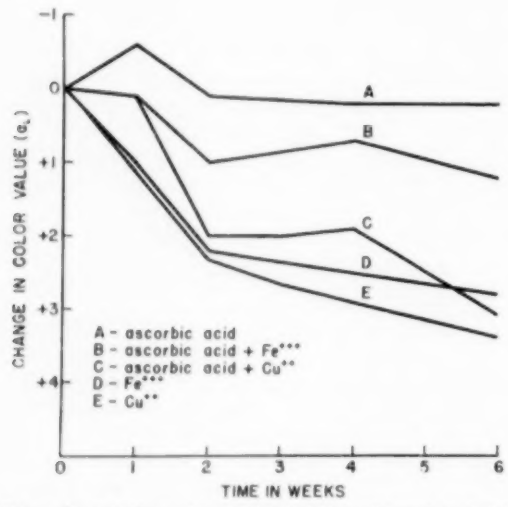

Figure 4. Relative rates of discoloration of kraut containing added ascorbic acid (200 mg./lb.), ferric (10 ppm.) and cupric (3 ppm.) ions, and stored at 45° F. in the dark.

effect in the presence of ferric ions, but provides little, if any, protection from the catalytic effect of cupric ions, at the levels indicated. In previous studies it was observed that darkening of kraut was relatively slight in the presence of the added ferric ions, when maintained at a low oxygen level *(16)*. A comparison of the rate of darkening of the kraut, and of the centrifuged juice may be seen in the curves shown in Figures 4 and 5. Added cupric ions caused darkening of the solid portion of the kraut (shreds and particles) but little change in color of the clarified juice.

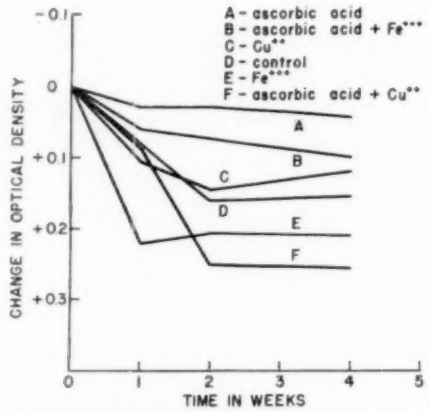

Figure 5. Optical density of the centrifuged juice from kraut containing added ascorbic acid (200 mg./lb.), ferric (10 ppm.) and cupric (3 ppm.) ions and stored at 45° F. in the dark.

Samples Stored at 45° F. (7.2° C.) Exposed to Fluorescent Lights

Kraut, as packaged in flexible bags, is commonly sold from open refrigerated cases illuminated by fluorescent lights. The deleterious effect of the radiation on the color and flavor of plain kraut and that to which copper and iron had been added has been shown *(16)*. Although addition of ascorbic acid was beneficial to kraut stored in the dark (except in the presence of added copper) it did not provide any significant protection to the kraut exposed to the light as shown in Figures 6 and 7. It was found that continued exposure of kraut containing added ascorbic acid caused its color to be darker than when

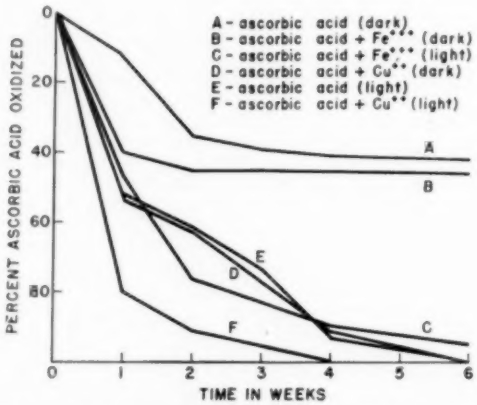
A - ascorbic acid (dark)
B - ascorbic acid + Fe+++ (dark)
C - ascorbic acid + Fe+++ (light)
D - ascorbic acid + Cu++ (dark)
E - ascorbic acid (light)
F - ascorbic acid + Cu++ (light)
PERCENT ASCORBIC ACID OXIDIZED
TIME IN WEEKS

Figure 6. Relative rates of oxidation of added ascorbic acid (200 mg./lb.) in kraut stored at 45° F. as affected by ferric (10 ppm.) and cupric (3 ppm.) ions and exposure to fluorescent light.

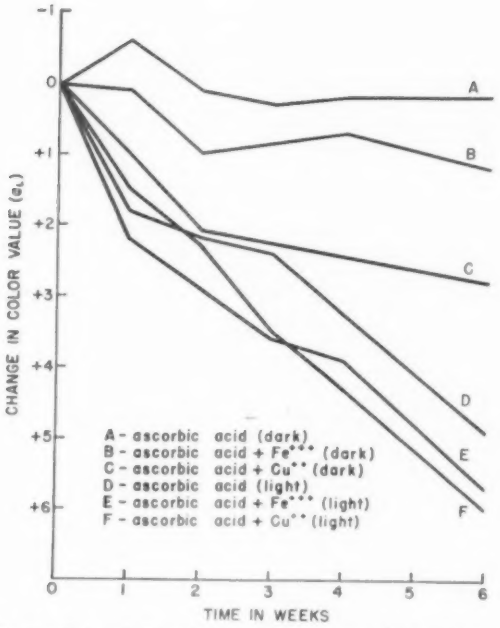

Fig. 7. Rate of discoloration of kraut containing 200 mg./lb. added ascorbic acid stored at 45° F. as affected by ferric (10 ppm.) and cupric (3 ppm.) ions and exposure to fluorescent light.

no acid was added. In the presence of air, and under light, both ferric and cupric ions accelerated the darkening of the kraut to which ascorbic acid had been added. The discoloration occurs even when a reasonable amount of ascorbic acid is still present. The change in the optical density of the clear centrifuged juice from such kraut samples exposed to light is shown in Figure 8. The curves indicate there is greater darkening of the juice, also, in the presence of added ascorbic acid, when the kraut is exposed to the light, in contrast to that stored in the dark.

Effect of Added Ascorbic Acid on Flavor

In general, flavor defects in kraut are associated with the darkening in color. Metallic contamination, especially of copper, which accelerates darkening, contributes a certain off-flavor. Exposure to fluorescent radiation causes also an activated flavor in the kraut *(16)*. The addition of ascorbic acid is beneficial to the flavor of the kraut stored in the dark when no metallic contamination occurs; it is not, however, effective in the presence of added metallic ions. It does not protect the kraut against the development of the activated flavor caused by exposure to light.

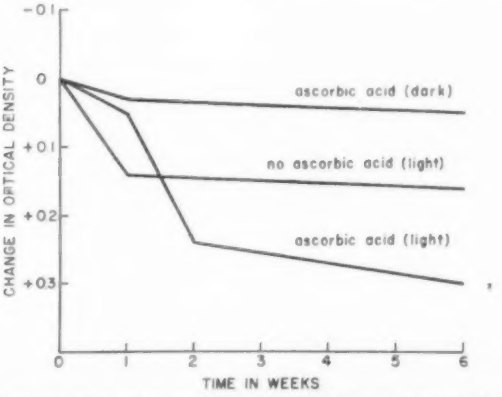

Figure 8. The effect of fluorescent light on the optical density of centrifuged juice from kraut containing added ascorbic acid (200 mg./lb.) and stored at 45° F.

DISCUSSION

In the presence of cupric ions ascorbic acid undergoes a process of autooxidation. In relatively acid solutions (below pH 4.5) dehydroascorbic acid seems to be the main product of the oxidation. It has been assumed that in the initial stages the reaction mechanism consists of the slow oxidation of the ascorbate ion by cupric ion to one with a semi quinone-like structure followed by its oxidation by oxygen to dehydroascorbic acid. Cupric ion concentration is maintained in the reaction by oxidation of cuprous ions by oxygen *(5)*. Hydrogen peroxide is a terminal reaction product of the aerobic oxidation of ascorbic acid catalyzed by cupric ions *(5, 17)*. In solutions of pH less than 4.5 all the hydrogen peroxide either oxidizes ascorbic acid or is decomposed. Both reactions have been reported to take place readily with freshly formed hydrogen peroxide in the presence of copper *(11, 12, 15)*.

It has been suggested there is probably no known inhibitor which can prevent the complete oxidation of aqueous solutions of ascorbic acid exposed to oxygen for several days *(14)*. The only practical method of preserving such aqueous solutions is to exclude air.

In the absence of metallic ions, added ascorbic acid acts as an antioxidant, taking up available oxygen and protecting the quality of the kraut stored in the dark. The absence of available oxygen minimizes the effects of contaminant ferric ions. In the presence of copper, however, autooxidation occurs with the production of hydrogen peroxide which may be indirectly responsible for further oxidation of the added acid and the darkening of color of the kraut.

The marked effect on color by exposure of the kraut to fluorescent light is evidently due to the generation of some organic peroxides causing the oxidation of the chlorophyll *(10)*. Also it is probable the formation of hydrogen peroxide by the catalytic effect of copper in the autooxidation of ascorbic acid will contribute to further oxidation of the ascorbic acid and the discoloration of the kraut.

The validity of the suggested role of the various factors in the discoloration of kraut was demonstrated in a separate series of tests. Samples of the processed kraut were packed in glass jars. To these were added, respectively, a dilute solution of hydrogen peroxide, a dilute solution of cupric chloride and hydrogen peroxide, and to the third, a solution of cupric chloride, hydrogen peroxide and ascorbic acid. A similar series was prepared using ferric, instead of cupric, ions. The jars were capped under 12 inches vacuum, and stored at room temperature exposed to daylight. Within a very short period of time (minutes) it was observed that in the presence of hydrogen peroxide cupric or ferric

ions caused discoloration of the kraut. Addition of ascorbic acid delayed discoloration until 3 days later when darkening was observed in all samples. In the samples containing ascorbic acid, hydrogen peroxide and ferric ions, bulging of the caps occurred due to accumulation of evolved gas, whereas in the presence of added hydrogen peroxide and cupric ions, none was observed. Autooxidation occurs in the presence of copper, whereby the ions change from the cupric to cuprous form. Any oxygen that is evolved during the process is taken up by the cuprous ion which is oxidized to the cupric state. Later it was noticed that the samples with copper and hydrogen peroxide underwent bleaching and continued to be lighter in color than all the other samples.

SUMMARY

Ascorbic acid provided good protection for the color of kraut packed in pliofilm bags and kept under refrigeration in the dark for the duration of the experiment (6 weeks). The ascorbic acid is reasonably effective in the presence of ferric ions, but is not in the presence of cupric ions, at the levels indicated.

Ascorbic acid is not effective in protecting kraut against discoloration or flavor deterioration when exposed to radiation from fluorescent lights. In effect, discoloration is apparently accelerated in kraut containing added ascorbic acid and exposed to such radiation.

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Functional Additives in Modern Food Processing[a]

CHARLES N. FREY[b]

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The food technologist occupies a critical position in respect to the public, to government, and to industry. In the course of his work and in the exercise of his responsibilities, he must clarify for the public and for various government agencies the problems of the food industry and justify the use of some of the processes employed by the manufacturer in their solution. Aware, as he is, of the functions which various chemicals perform, both in relation to modern methods of production and in relation to the ultimate food value of the food chemically treated, it is on him, the technologist, that management depends for suggestions as to the use of chemicals in processing. It is therefore the responsibility of the technologist to keep management informed in respect to every aspect of this complex situation involving chemical additives in food. It is the purpose of this paper to explore some of the necessities, the benefits, the hazards, and the controls that are present—and sometimes entangled—in the modern use of chemicals in foods. This is a problem that should be given more consideration by food technologists for in so doing they can serve the interests of their profession, the industry, and the public.

BACKGROUND FACTORS

The food industry is continually facing new responsibilities. In the early days of our country food preparation was carried on chiefly in the home and in small establishments. Today food preparation has become largely a matter of factory production. A large percentage of our food has had some type of processing before it reaches the consumer's kitchen, and many foods—except

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for heating or dilution—are ready to serve at the table. In this transition from home to industry the new responsibilities mentioned earlier have evolved—the exacting requirement of sanitation, for example, and the prime importance of retaining nutrients. The industry has become aware over the years that some types of processing lower the content of vital factors in nutrition; namely, vitamins and amino acids. There are also losses of minerals and carbohydrates in certain types of processing. This newer knowledge of nutrition has opened up vast fields of activity for the food industry and science has been put to work on a magnificent scale to study the means of sanitary processing whereby sterile foods may be produced with a minimum loss of invaluable ingredients.

As science entered the industry, investigators found that many processes were difficult to carry on under factory conditions. A new era began with the introduction of chemicals to facilitate processing, to improve stability or nutritive properties, to cut down marketing losses and to improve consumer acceptance. The addition of chemicals to foods has, of course, been practiced for many years; for example, consider the long use of vinegar and of baking powder. But the significance of many types of additions in terms of public health was not fully appreciated until biochemical science had matured. The older generation will recall the alum, tartaric acid baking powder controversy and also the sodium benzoate controversy.

The phrase "chemicals in foods" may connote in the minds of some something unnatural in foods. However, all foods are chemical elements or compounds. Chemicals added to foods should harmonize, of course, with those naturally present in the products we consume. We shall define "chemicals," for the purpose of this discussion, under two categories; a, intentional additives, such as vitamins to enrich bread, and b, incidental additives, such as residues which may remain after the use of pesticides or sterilizing agents.

USES OF ADDITIVES IN FOOD PROCESSING

Let us look for a moment at this matter of chemicals in foods from the standpoint of industry. Manufacturers have difficult production problems in connection with the manufacture of the numerous food products used in America. Means of saving time and methods of improving manufacturing procedures, such as improving the quality and shelf life of the product in order to obtain better consumer acceptance, are important goals for every technical and production department.

The American housewife formerly made a loaf of bread in the kitchen under relatively simple environmental conditions. However, to make tons of bread in the bakery and to make this bread uniform in color, in loaf volume, taste and flavor, and without destruction of its nutritive elements, is quite another problem. The food processor has invoked the use of the chemist's knowledge to study process control. Chemical substances are added to flour at levels which are harmless in order to stabilize them and properly age them. This procedure enables the baker to make a loaf of bread of uniform quality and volume from flours that vary greatly. This practice came into operation about thirty years ago when the baking industry became mechanized.

The use of chemicals as a public health measure has been practiced for some time on a nation wide basis in connection with the enrichment of bread. The addition of such chemicals as vitamin B_1, riboflavin, nicotinic acid and iron to bread to improve its nutritive properties is an excellent example of the wise use of our chemical knowledge. This procedure offers a means of combating nutritional deficiencies on a national scale. It restores to white bread, the type of bread most widely used and desired, the more important ingredients removed by the milling process. This means of improving bread has received approval of Food and Drug Administration, public health officials and most of the doctors and nutritionists in the country. A recent survey indicates that enrichment of cereals has had a marked effect on the health and well-being of the people of Newfoundland.

The use of high melting fats in the production of margarine, and the use of chemicals to color margarine and butter are further examples of the effects of chemistry on food production. Years ago benzoic acid was used as a preservative in the preparation of catsup, but its use was found to be unnecessary when better operating equipment was developed. Recently calcium salts have been used in the treatment of Macintosh apples to give the slices the consistency, when used in pie making, normally obtained with Baldwin and Northern Spy. Ascorbic acid has been used to prevent browning of frozen peaches and apples. It has also been used as an oxidant for flour. Sulfur dioxide has also been used for the prevention of discoloration of apples and other fruits. Additions to milk were formerly forbidden by law, but the addition of vitamin D is permissible today because it is believed to be in the public interest. Calcium salts are of great nutritional importance. Their inclusion in the bread standards as optional ingredients indicates that the Food and Drug Administration has approved their use from a public health standpoint—although 25 years ago the inclusion of calcium salts in bread was not well received. One of the common diseases of childhood, rickets, has practically disappeared since the use of vitamin D and of products rich in calcium salts has been encouraged. Studies made by nutritionists indicate that calcium is deficient in many of our diets. Consequently, additions of calcium salts, such as phosphates, carbonates and sulphates as conditioners in making bread, improve the nutritive properties of bread. Studies at the American Institute of Baking indicate that a pound of bread made with at least 3-4% dry skim milk supplies approximately one-third of the daily calcium requirements of an individual.

Emulsifiers. A number of years ago shortening containing monoglycerides and diglycerides was introduced. These improved shortenings enabled the baker to make a cake of much higher sugar and fat content than had been possible prior to this discovery. This richer, better quality cake resembled the cake made by the housewife, and thus the baker gradually increased his production and took over the work which the housewife formerly performed in the kitchen. Other emulsifiers competing with mono and diglycerides have been marketed and are accomplishing the same purpose, at least as effectively.

Emulsifiers of the monoglyceride and the polyoxyethylene types have been widely used in bread for a number of years. Bread prepared with emulsifiers has had better consumer acceptance than bread without emulsifiers.

Recently (May 15, 1952) the Federal Security Agency *(5)*, Food and Drug Administration, issued standards of identity for white bread, enriched bread, raisin bread, milk bread and whole wheat bread, and corresponding rolls and buns. The polyoxyethylene monostearate emulsifier (Myrj 45) was not included in the standards. The Food and Drug Administration rejected the inclusion of the polyoxyethylene type of emulsifiers on the ground that emulsifiers in bread do not permit the consumer to determine the age of bread when purchased. Although there has been no definite evidence of injury from the use of Spans, Tweens or polyoxyethylene monostearate—in amounts in which they are likely to occur in the diet from their use in bread—the investigational work does not definitely establish their safety and the record does not permit a conclusion that bread containing them is safe for continuous use over a human life span, according to the statement issued by the Food and Drug Administration.

Exclusion by the bread standards order, effective August 13, 1952, of polyoxyethylene monostearate and other emulsifiers of similar nature has been stayed, pending decision on a petition for review of this order which is to be heard in the fall of 1952 by the United States Court of Appeals for the 3rd Circuit. In the meantime use of polyoxyethylene types of emulsifiers is permissible.

Other additives. Calcium propionate has been found to be specific in the prevention of mold. It is found naturally occurring in cheese, but has recently been used to prevent the growth of mold in bread and cake when held in the consumer's kitchen. There was considerable opposition to the use of this product, but recently its use has been approved.

Copper was formerly regarded as a highly undesirable contaminant in foods, but Hart at Wisconsin found that small amounts of copper are necessary in the diet in order that the body may properly use iron. Fluorine was also considered a harmful ingredient in food products and water supplies, but today cities are experimentting with the use of fluorine in drinking water with the object of preventing dental caries.

The products of the chemical industry have played a vital part in the development of foods that are nutritious and safe and essential to the strength and welfare of the American people. Fertilizers have enabled farmers to increase production. Pesticides have reduced the ravages of agricultural pests.

Antioxidants have prevented spoilage and loss, thus increasing the quantity and quality of the food reaching the market. Lard, an important farm product, was almost driven from the home because it lacked stability and was replaced by hydrogenated oils. Now, with antioxidants, lard is back as a shortening.

Incidental additives. Those who criticize the production practices of our farms must consider the problems of the farmer. The production of food on the farms has become more difficult as agriculture becomes adjusted to high production and to a single crop program. Insects and bacterial diseases thrive and are difficult to eradicate, necessitating the use of pesticides to enable the farmer to grow a satisfactory crop. These pesticides are compounds that are generally toxic to human beings as well as to the pests they are expected to eliminate. As a result, the practice of spraying becomes of great significance to the food processor. He must constantly check his product to see that toxic residues are not present on the processed food product to such a degree that harmful results will follow the use of the manufactured product by the consumer. The fact that foods are constantly subjected to treatment of various kinds from the time the soil is fertilized until the consumer uses the product, indicates the complexity of the problem. We are not faced with the problem of a single addition, but addition of a multiplicity of compounds which have been used during the production and processing of a food product. Recently antibiotics have found wide use in feeding animals, especially chicks and pigs. Vitamin B_{12} and antibiotics enable the farmer to grow animals at a normal rate or above on cereal proteins. Certain emulsifiers of the poly type also have shown interesting results when substituted for antibiotics.

The use of antibiotics in treating cows for certain diseases has produced problems in connection with butter making and has raised certain difficulties in feeding infants. Certain insecticides when applied to cows have been found in the milk and made the milk unfit for infant feeding. However, we cannot in view of the practical need for pesticides, which have markedly increased productivity when used with plants or animals, entirely eliminate their use, but greater care in selecting pesticides will be taken as the result of this experience. In order to guarantee our food supply we may be compelled to accept certain hazards and strive to the utmost to reduce them to a point when no harmful results will be encountered.

Other incidental additives. Addition of controlled amounts of alkaline material in the production of canned peas has enabled the canner to preserve the natural color of the peas. The addition of calcium salts to canned tomatoes has assisted in maintaining the integrity of the slices of the canned tomatoes. The waxing of citrus fruit has enabled the producer to maintain the fresh qualities of a number of fruit products, and treatment with gaseous agents to control spoilage and decay, has been used extensively and effectively. A short-time method of producing bacon has been developed. The new method consists in introducing a controlled amount of cure into each slab of meat through many injectors, followed by 24 hours' immersion in brine to complete the curing of the bacon. Additives, such as lecithin, mono and diglycerides, to margarine prevent leakage and splattering on frying, and produce emulsifying action.

The addition of vitamin A to margarine has been an important step in improving a widely used food. This public health measure is approved by the Food and Drug Administration and by the Public Health Service.

Use of iodized salt has reduced the incidence of goiter. Flavors, colors, and humectants and stabilizers have improved the texture, appearance and appeal of foods. Plastics and film wraps have improved the sanitary handling of foods and made modern food marketing possible.

The use of citric or tartaric acid to produce quick-setting gelatin has saved many a housewife from having her dinner ruined by the failure of gelatin to set properly.

The use of citrates and phosphates in processing evaporated milk to prevent curdling is a well established practice.

The limited number of examples given in connection with the use of chemicals is sufficient to indicate they have been widely used in the production and manufacture of food. They have assisted the processor in making a more saleable and, in many cases, a better tasting and more nutritious product. The Food and Drug Administration has cooperated in the development of many of these processes involving chemical additives by including them in the standards, or by assisting in developing assay procedures. According to a recent statement made by Foulger *(10)* of the du Pont Company (M.C.A. meeting, January 15, 1952), this progress has been accomplished without harm to any individual. I quote, "Actually, so far as the FDA reports show, no single death is known to have resulted in the period surveyed from the use in or on foods of chemicals intended for such a purpose."

Food processors assume new responsibilities when they add chemical products to their processed foods. They must maintain consumer confidence in the established product produced by the manufacturer. Industry must consider the public good. The manufacturer must seek to establish the degree of toxicity or the health hazard, if any, involved in the use of the additive. He must show that the additive has a useful function and is not being used to make food appear better when it is intrinsically less valuable. He must determine if it is in the public interest to add the chemical, and if the consumers prefer and select the product treated with the additive. It is essential that the food processor cooperate fully with the U. S. Food and Drug Administration to establish, as well as the present procedures permit, the non-injurious character of the additive at the levels employed. The manufacturer should not forget to educate the public in connection with changes made in the product. If he does not do so, misunderstanding may arise.

CHEMICALS UNDER ATTACK

The use of chemicals in the food industry has not always been well understood by the public, and repercussions have resulted. We shall attempt to point out only a few of the recent cases. An article by Congressman Delaney *(8)* entitled "Peril on the Food Shelf" appeared in *The American Magazine* of July, 1951. Representative Delaney states that "A tragic legal joker permits us to become a nation of 150 million guinea pigs guilelessly testing out chemicals that should have been tested adequately before they reached our kitchen." Bakalar *(3)* in *Vogcant* tells the story that "our bread is phony right from the start."

In the July issue of *Consumers' Union* Harold Aaron *(1)* discusses "Chemicals in Foods."

A few months ago Louis Bromfield *(6)* broke out from his peaceful retreat on an Ohio farm to warn the public about "The Poisoned Food We Eat." I quote from Bromfield's paper: "Many of the poisons used are not merely old-fashioned arsenic which we know is lethal and which we know accumulates in the human organism rather than being eliminated. Many of these poisons are strange and new. They are the products of the new super-chemistry which turns out new and violently lethal products almost weekly. These in turn are rushed into use, advertised everywhere and sprayed and dusted over virtually everything we eat before anything whatever is known concerning their effect upon our health, our capacity to reproduce our kind or in general our well-being. Often this indi-criminate use is actually recommended by government agencies such as the Department of Agriculture."

An article by Rorty *(22)* in *The New Leader*, December 17, 1951, is entitled, "On the Coming Revolution in Bread."

These men give the impression that the chemical and food industries are selling chemicals which have not been adequately tested and that serve no useful function in foods. Obviously such statements as have been quoted have been made for political purposes and are unjustified; there is no factual basis for them.

The facts in the case. For a comprehensive review of the whole subject of chemicals in foods one should read the papers given at the Inter-industry Conference on Chemicals in Foods sponsored by the Manufacturing Chemists' Association (Statler Hotel, New York, January 15, 1952). The nutritional as well as the legal field was thoroughly reviewed.

REACTION OF BRITISH SCIENTISTS TO CHEMICALS IN FOODS

The position taken by some British scientists may be represented by citing a paper of A. C. Frazier *(11)* under the title "Synthetic Chemicals and the Food Industry." He defines a chemical as a substance added to or present in food for various purposes; namely, chemicals added intentionally to improve a food or replace a natural food, or a substance present as a contaminant. The use of chemicals is on the increase. The fact that the health record is good should not prevent concern. Some products taken in food exert their deleterious action over the years. However, he states, we must be realistic. To prevent the use of chemicals entirely is to be ignorant of modern food technology. The natural food is not inherently safer than the synthetic. There is a difference between the use of chemicals as drugs and chemicals used in foods. The former is usually very toxic; toxic may refer to varying degrees of response, and the drug is given under supervision and in small amounts, usually for short periods; whereas in the case of foods, large amounts are consumed over a life time. Chemicals accumulate in the body when the rate of loss by excretion or oxidation is less than the intake. Toxic effects may become evident in a variety of responses: visceral damage, changes in functional activity of tissues and changes in structure. Some chemicals interfere with nutritional values of food, such as mineral oil and paraffin, high melting fats. Saccharine sweetened water may be used to replace fruit juice. Certain chemicals may interfere with enzyme action. Others may oxidize or destroy factors in food—as rancid fat destroys vitamins A and E.

To protect the public, tests are carried out on suspected chemicals *(11)* for example, acute toxicity tests and chronic toxicity tests. Dosage of 1 mg. per pound body weight if not lethal indicates the substance is relatively non-toxic. Chronic toxicity tests may cover the life span of the animal. Test experiments may be carried on for periods of months or years. The animals are observed for loss of appetite, vomiting, diarrhea, loss of weight. The foods used in the test are prepared as they are given to man. The chemical is tested in relation to this food and without this food. It should be studied in relation to fat especially, and to all other foods. Dogs, rabbits, guinea pigs and rats may be used; monkeys have been suggested. However, these animals are vegetarians, subject to many diseases not known physiologically, and do not seem suitable. The final test, however, is the human subject, inasmuch as the animal tests cannot be conclusive. This is difficult to arrange, but if preliminary tests on animals have been completed, they are justified. A general distribution experiment or a controlled experiment may be carried out.

Too high concentration of test material is not realistic, according to Frazier *(11)*. However, some margin of safety must be set. Dosage should be set in relation to use and the properties of the chemical. The basis should be the proposed standard dietary intake. If the chemical is fed in long term experiments at levels of 100 times standard dietary dose, and no harm results, it is reasonable to conclude that the chemical may be safely used. Over 10 parts per 1000 of diet require special tests. The number of animals employed should be based on statistical requirements. The design of the experiment is very important. Animals are placed on a good diet, as there is likely to be less resistance on a poor diet. Unfortunately optimum conditions of diet do not usually prevail in the case of the human being.

A recent paper by A. T. Parsons *(20)*, is of interest. The limits of permissible levels of a number of chemicals found in or added to foods, such as nickel, copper and lead, are given. Analyses of a number of foods giving the normal content of copper, iron, zinc, arsenic, fluorine, manganese, selenium and aluminum are also given. Parsons suggests that a system of legal tolerances is desirable, but the manufacturer should not allow such limits to slacken his efforts to improve the purity of his product. As expressed by Monier Williams, "Until it can be shown conclusively that a given quantity of a particular foreign substance is absolutely harmless and devoid of any remote toxic effect, it should as far as humanly possible be kept out of food."

Charles A. Adams *(2)*, *C. B. E.*, a member of the Ministry of Foods, states that the Medical Research Council agreed that possible dangers from novel substances in food, food processing agents, and food contaminants should be kept under continuous observation, but advised that no new measures were at present required to control dangers from medicines and other consumer goods.

The following statements by the President *(21)* of the Advisory Council on Scientific Policy, Great Britain, are of interest:

"The risk to life and health due to the presence of toxic substances in consumer goods is probably small, but the rapid growth of the chemical industry, and the needs of the food-processing industries for substitutes to replace scarce materials or for chemical substances which have a claim to use on their own merits as improvers of the appearance, palatability or texture of manufactured foods, are accelerating the pace at which new chemical substances are being introduced into consumer products, and the machinery which exists for testing the possible harmful effects of these substances is inadequate.

"In accordance with the recommendation of the Committee on Toxic Substances in Consumer Goods, adequate and fully effective arrangements should be made for the acquisition by departments of information about possibly noxious substances or processes which industry may contemplate using, before these are allowed to find their way into the composition or treatment of the articles concerned, and that it is proper for the departments to decide on the method of obtaining information which is best suited to their needs and to their experience of dealing with industry. We are in agreement with the view expressed by departments that new legislation need not be introduced at present, and we recommend that the problem should be brought to the attention of manufacturers and that they should be informed that they are expected to take all reasonable care to ensure that no new substances should be offered for sale if toxic effects are suspected.

"A standing committee consisting of representatives of the departments mainly concerned should be set up in order that there may be a central organization to which Government departments may turn for advice.

"The Medical Research Council should retain the general responsibility of keeping the whole problem of toxic substances under review, and of initiating research; and that they should receive adequate financial provision to allow any necessary expansion of their present program of work in this field, including the development of information services.

"Information over the whole field of toxic substances should be interchanged with the appropriate authorities in other countries and particularly with the Food and Drug Administration and other Government agencies in the U. S. A."

EVALUATING THE HAZARDS OF CHEMICALS IN FOODS

As our knowledge of chemistry has increased, the methods of appraisal of certain constituents of the diet have become increasingly more complex. There is

always the danger that these methods of appraisal will become so complex as to hamper progress. The history of the use of chemicals indicates quite definitely that the idea of the development of all possible information is not always necessary before obvious benefits can be obtained by use of the chemical. This is not to say that proper toxicological evidence is not necessary. We must evaluate the hazards, if any are involved, at the level at which the compound is used. However, it is not possible for us to know all the manifestations metabolically and otherwise which the chemical compound may exert. Where to draw the line is the problem facing us in many instances today. Let us not underestimate the potentialities we invoke by undertaking the addition of chemicals to our food prior to adequate toxicological studies. A recent paper by Dr. Oser *(19)*, one by J. L. St. John *(23)*, and another by F. C. Bing *(4)* contain interesting and comprehensive discussions of this problem. Interesting comments on the use of chemicals in baked products may be found in a paper by A. J. Amos.[e]

Levels of spray residues remaining on fruits of various kinds were considered in the pesticide hearings of the Food and Drug Administration. Very important problems are unsolved. It is necessary to maintain our present rate of food production; however, this is not possible unless pesticides are employed. The Department of Agriculture and the Food and Drug Administration have taken a realistic view of the situation. Every means of protecting the public from injurious effects resulting from the use of toxic sprays will be carried out, and we may rely on the integrity of government officials involved and on industry for the rigid control that will insure safety to the consumer.

The toxicological procedures employed in pesticide evaluation are in general based on the procedures used for evaluating the toxicity of chemicals, regardless of the end use of such material. The emphasis and scope of the procedure are matters of individual consideration in the case of each chemical. To be of value the toxicological tests should be contemporaneous with the developmental studies of the compound. If the substance shows promise, further expansion of production facilities can be undertaken, and the studies of its potentialities in practice can be carried on. As Hazelton *(13)* stated at the recent A. C. S. meeting (New York, September 1951), we finally reach a stage wherein investigations on the mechanism of action, antidotes, excretion, or other fate in the body, accumulated potentials, specific hazards in application, methods of removal, levels found in consumers' food and levels at which substances in foods become a health hazard, can be evaluated.

One can visualize further studies on the effects of feeding various levels of the substance under test to various species of animals. A lifetime feeding test at levels which might be ingested daily, or 5 to 10 times these levels, as well as reproduction studies are desirable. Determination of acute toxic levels is recommended. Chemical tests may not always differentiate certain compounds satisfactorily; consequently, biological tests may be necessary. Horsfall *(15)* at the New York A. C. S. meeting (September 1951), stated that although chemically one cannot differentiate among various samples of copper oxide, fungi in the presence of various oxides will show marked differences in growth. Zinc ethylenebisthiocarbamate and zinc dimethyldithiocarbamate cannot be differentiated chemically; but they can be differentiated by biological means.

Dr. Francis F. Heyroth *(14)*, Kettering Laboratory, stated at the A. C. S. meeting (New York, September 1951), that the current practice in evaluating chronic toxicity of a pesticide consists in incorporating it in various proportions in the food supplied to groups of animals of various species for periods up to their total life span. The rates of growth, utilization of food, fecundity and mortality, the weights and histo-pathologic appearance of the organs are observed. By the use of appropriate analytical methods, its rate of excretion, the sites, extent and duration of storage in the issues, and its metabolic fate may be learned. Utilization of such data in evaluating the hazards to man from the use of a new pesticide involves much uncertainty, especially if the response in different species varies, and if species become resistant. To overcome this uncertainty, the employment of human experimentation of the types formerly conducted during the existence of the Remsen Referee Board of Consulting Experts is suggested. Large scale experiments in connection with the use of fluoride in drinking water provide a pattern for determining optimal concentration and use of a chemical.

ROLE OF FEDERAL AGENCIES

The Food and Drug Administration has developed a number of methods for determining toxicity of foods. Papers by W. B. White *(21, 25)*, and the article by Lehman *(16)* describe methods and procedures. They advocate the use of acute toxicity studies and also chronic toxicity studies covering the life time of the animal. At least three species of animals should be used. Reproduction studies should also be carried on.

Satisfactory agreement among scientists on the procedures to employ in order to determine hazards and toxicological behavior of intentional additives and incidental contaminants in foods has not been reached. Recently toxicologists have developed new concepts in regard to methods of determining the toxicity or health hazard involved in the use of chemicals used in various food products. Increased knowledge concerning the metabolism of the body has made it possible to understand more specifically what the reaction of certain chemicals may be when taken into the body for considerable periods of time. Animal tests based on the newer knowledge have given us more comprehensive means of evaluating the responses obtained. We must realize, however, that there is no absolute factor of safety in respect to any food we consume. Individuals also vary in the response to certain foods and chemicals.

The Food and Drug Act of 1938 permits setting up standards of identity for certain food products. Public hearings are held for presentation of evidence in respect to the inclusion of certain compounds the manufacturer wishes to introduce into the standardized product.

[e] In discussing problems arising from the use of chemicals in foods, specifically flour and bread improvers and flour bleachers (*Chem. & Ind.*, 946-50, Nov. 10, 1951) the author asserts the belief that no hazards are involved under present usage.

These hearings, which are really courts of law inasmuch as the testimony becomes a legal reference, are not, in my estimation, the place to determine scientific facts in respect to the inclusion of certain ingredients, and the evidence as to their freedom from toxicity. The method of presenting scientific evidence to the Food and Drug Administration should be given further study.

It is believed that presentation of scientific data may be more effectively handled by committees meeting in conference rooms with the Food and Drug Administration and not in open hearings connected with the development of standards.

Perhaps standards are not the best solution, in all cases, for the problem of protecting the interest of the consumer. More effective labeling may be more informative and give greater latitude to the manufacturer in meeting consumer demands without impairing safety or endangering quality.

The introduction of chemicals has expanded the activities of the Food and Drug Administration from that of checking on the composition, purity, sanitation, and labeling to one of far wider scope. Toxicology, nutrition, physiology, pathology, histology, biochemistry, organic, physical and analytical chemistry, physics, and statistical analyses are involved. Earnest cooperation between industry and its scientific staffs, and those of the Food and Drug Administration are necessary in order to make control effective, and the operation of both industry and government work smoothly. In addition to the control exercised by the Food and Drug Administration, the Bureau of Animal Industry of the United States Department of Agriculture is responsible for the control of meat and meat products. The Insecticide Division of the United States Department of Agriculture controls the registration of pesticides, their ability to control pests, safety for use, effect on other forms of life, on soil et cetera. The United States Public Health Service is responsible for the prevention of hazards to the health of the public in connection with the use of pesticides.

THE FOOD PROTECTION COMMITTEE OF THE NATIONAL RESEARCH COUNCIL

The methods for determining the toxicity of chemicals are beyond the scope of this discussion. The Food and Drug Administration has made many contributions in this field. However, it is not possible for a small group in the Food and Drug Administration to carry the entire burden of research and responsibiliy for control.

In order to assist effectively the Food and Drug Administration officials, the public and industry, a Food Protection Committee has been organized by the National Research Council's Commitee on Food and Nutrition. This Committee is purely advisory. In accord with the principles of the National Research Council it will maintain its objectivity and independence.

The Food Protection Committee has obtained the assistance of liaison panels drawn from industry, trade associations, and government agencies. This representation serves as a two-way channel for the flow of information between their respective organizations and the Committee. Subcommittes on toxicology, pesticides, chemistry and food technology have been formed.

The Committee proposed to carry out a number of important functions which are as follows:

1. The Committee will assemble scientific information on both incidental and intentional additives, which are used or proposed for use in or on foods, and will summarize and evaluate this information, and make its conclusions available in usable form to those interested.

2. The Committee will advise and assist industry and Federal and State governmental agencies in the integration of research on the utilization of chemicals in food production, processing, and preservation, and promote additional research, by existing agencies, which in the opinon of the Committee appears desirable in the public interest. The Committee itself, however, does not propose to conduct or finance research.

3. The Committee will seek to develop guiding principles and standardized procedures essential to safeguard food.

4. The Committee will encourage and aid in the distribution of accurate scientific information to the general public.

The Committee recently made available three statements as follows: Statement on the Use of Surface Active Agents in Foods *(9a)*, November 1951; Summary of Progress and Projects *(9b)*, November 1951; and Use of Chemical Additives in Foods *(9c)*, December 1951. It also issued *Basic Principles Involved in Evaluating Safety in the Use of Chemical Additives in Foods (9d)*, June 1951. The Committee is presently engaged in a study of procedures for evaluation of the safety of chemical additives. Its work will undoubtedly prove to be of great assistance to government agencies and to industry. The Committee offers a platform on which industry and government with the assistance of selected scientific talent can work out problems of common interest in a democratic manner.

THE DELANEY COMMITTEE

Congress in 1950 appointed a committee (the Delaney Committee) to investigate the use of chemicals in foods. The resolution (HR323, 81st Congress, 1st Session, June 20, 1950) authorized and directed the committee to conduct a full and complete investigation of the following:

"1. The nature, extent, and effect of the use of chemicals, compounds, and synthetics in the production, processing, preparation, and packaging of food products to determine the effect of the use of such chemicals, compounds, and synthetics (A) upon the health and welfare of the Nation, and (B) upon the stability and well-being of our agricultural economy;

"2. The nature, extent, and effect of the use of pesticides and insecticides with respect to food and food products, particularly the effect of such use of pesticides and insecticides upon the health and welfare of the consumer by reason of toxic residues remaining on such food and food products as a result of such use; and

"3. The nature, effect, and extent of the use of chemicals, compounds, and synthetics in the manufacture of fertilizer, particularly the effect of such use of chemicals, compounds, and synthetics upon (A) the condition of the soil as a result of the use of such fertilizer, (B) the quantity and quality of the vegetation growing from such soil, (C) the health of animals consuming such vegetation, (D) the quantity and quality of food produced from such soil, and (E) the public health and welfare generally."

When the findings of the Delaney Committee are released,[4] they should be of great interest.

THE MILLER BILL

Congress has entertained several bills with the object of creating legislation increasing the power of the Food and Drug Administration to control the use of chemicals. The Delaney Committee during its investigations heard considerable testimony with respect to legislation involving provisions in the law similar to the new drug section of the Federal Food, Drug, and Cosmetic Act of 1938. One of the bills proposed, the Miller bill, would provide that an additive before being permitted in food distribution must have been cleared as to its freedom from both acute and chronic toxicity by the Food and Drug Administration. Testimony in support of and in opposition to such legislation was given at the Congressional hearings by industrial and scientific groups connected with industry, government and universities.

RECOMMENDATIONS OF THE MANUFACTURING CHEMISTS' ASSOCIATION

The Manufacturing Chemists' Association after studying existing legislation and various proposals for new legislation relating to chemicals in foods, concluded that existing legislation vests the government with adequate authority over the use of chemical additives. They state that there is one area, where it can be argued the present law may need strengthening, and that is, in assuring that advance information is supplied by industry to the Food and Drug Administration with respect to proposed new uses of chemical additives (this does not include pesticides). Both the food industry and the chemical industry supply the Food and Drug Administration with a substantial volume of information on a voluntary basis with respect to proposed new uses of chemical additives.

Under the circumstances the MCA recommend that consideration be given to new legislation containing the following provisions:

a. On and after a given date (July 1, 1952, for example) there shall be no new use of any chemical additive in or on any food until 60 days after a notice of such intended use has been filed with the Food and Drug Administration.

b. The notice of intended use may be filed by either the chemical manufacturer or a food processor.

c. The notice of intended use shall report the applicable pharmacological and toxicological data available. The notice of intended use shall also report the known composition of the chemical additive, a method for the determination of how much of the chemical additive is in or on the food, and directions for the use of the chemical additive with respect to the specific food and the specific use that is proposed.

d. The notice of intended use shall be accompanied by samples of the chemical additive.

e. Within the 60-day period between the filing of the notice of intended use and the date when actual use may begin, the Food and Drug Administration may request the person or persons filing the notice of intended use to appear at its offices in Washington or elsewhere, for such conferences or discussions concerning the intended use as may be appropriate.

Under this proposal, once the chemical additive has been placed in use, the Food and Drug Administration will be in a position, in those instances where circumstances so require, to exercise the authority it possesses under existing legislation as discussed above.

NO SINGLE GROUP CAN SOLVE THE PROBLEM

It is evident that we have not arrived at a common understanding regarding the best means of protecting the public. We have in Mr. Crawford, Commissioner of the Food and Drug Administration, and his associates a group of men of the highest integrity and competence who have proceeded with their work in a cooperative and democratic way. No officials in our government have faced their duties with a higher sense of responsibility and with a greater spirit of cooperation than the scientist connected with our food and drug work. On

[4] Since this paper was written the Delaney Committee *(7)* has issued a report covering its findings. The report was signed by five members of the committee of six. A minority report filed by Congressman Walt Horan, the sixth member, and two reports covering additional views, one submitted by A. L. Miller and Gordon L. McDonough, and the other by Gordon L. McDonough, were also issued.

The majority report covers the original authorization by Congress under which the committee operated, the nature and scope of the problem; the use of chemicals in the production, processing, preservation, and packaging of foods, nitrogen trichloride, thiourea, para-phenetyl urea, lithium chloride, mineral oil, monochloracetic acid, dehydroacetic acid, emulsifiers; hormones in food production; the use of pesticides, DDT, chlordane, selenium, phenylmercury compounds, benzene hexachloride; the use of chemical emulsifiers to replace natural food substances in baked goods; inadequacy of present legislation; conclusions and recommendations.

The Committee concludes that "The increasing use of chemical additives in the production, processing, preservation, and packaging of food has created a serious public health problem. The evidence presented reveals that existing Federal laws do not provide complete protection to the public against the addition of chemicals which may be unsafe."

"Your committee recommends, therefore, that the Federal Food, Drug, and Cosmetic Act be amended to require that chemicals employed in or on foods be subjected to substantially the same safety requirements as now exist for new drugs and meat products. Adequate provisions for a comprehensive judicial review of administrative decisions should be included in such an amendment."

The two members, Miller and McDonough, issued a statement calling attention to the need for more work and further legislation in respect to chemicals in foods, estrogenic hormones in foods, and pesticides. They believe that more work should be done by industry before chemicals are released for consumption by the consumer. More study is required before the widespread use of estrogenic hormones is permitted. Pesticides that are extremely toxic should not be offered for public use without proper controls. "The general public needs more education and should be alerted at all times to the dangers when they are using some of these powerful new sprays and insecticides."

McDonough in his additional report cites the State of California as having one of the best state regulations to protect the public and the workmen engaged in the agricultural industry against serious hazards.

Representative Horan submitted a minority report indicating that his views were not in agreement with the majority. He states that the majority report is "alarmist" in nature. It would contribute to the difficulties of the producers of foodstuffs in the United States and yet add nothing of assurance to the consuming public. He states that "The Food, Drug, and Cosmetic Act of 1938 has given the Food and Drug Administration full authority to protect the public from any residue hazards from the use of pesticides through the establishment of tolerances."

He calls attention to the errors in the majority report in respect to the statement that 50,000 pounds of stilbestrol-treated chickens were seized and "condemned." He points out, "Following seizure, claims were filed in each instance, and, in condemnation decrees protected by adequate bond, salvage was permitted under the immediate supervision of an inspector of the Food and Drug Administration. . . . the edible portion of the bird was released for the market."

Further he states "that adequate legal processes are already in existence for the full protection of the consuming public."

The observation is also made that the Public Health Service for years has been studying the toxic effects of many of these chemicals on man, at Wenatchee, Washington, Savannah, Georgia, and in various Public Health Hospitals, and studies have failed to show a single case of chronic poisoning due to residue of pesticides chemicals in foods.

It is believed that the majority report is nonjudicial, and that certain members of the Committee were affected in their conclusions by preconceived ideas. Much more effort should have been made to stress the excellent work being done by the Department of Agriculture, land grant colleges, Food and Drug Administration, Public Health Service and industry to protect the public. There is a vast amount of sound work underway in government and industry laboratories designed to prevent any hazards. The interest of the public is a dominant influence in every industrial laboratory.

numerous occasions the present Commissioner of the Food and Drug Administration has expressed his confidence in the integrity of the food industry and his appreciation of the excellent progress industry has made in improving the quality of American foods.

On the other hand industry has also faced its responsibilities with the purpose in mind of improving its products and making them more acceptable to the consumer. It has kept in mind the protection of the consumer by avoiding the introduction of substances that at the levels used are harmful, or that are toxic when tested according to the techniques available. Industry is constantly on the alert to improve the physical as well as the nutritive properies of the product it produces. Mechanical operations often develop unfavorable reactions which tend to destroy the acceptability of the product. The manufacurer attempts to eliminate these difficulties in order to gain consumer acceptance. To control manufacturing operations, or the stability of a product, often necessitates the introduction of chemical compounds. It is to the credit of the American food industry that it has always maintained high standards and that no substance detrimental to the health of the public has been intentionally employed by any group of manufacturers. The record of the food industry is, indeed, an excellent one.

Those who doubt the integrity of the food industry should visit the scientists in their laboratories and the men in production. They will learn something about the sense of responsibility and the high character of those who have charge of our food production.

Contrary to some ideas that have been circulated, reliable food processors have not reduced the nutritional quality of our foods or created inferior products through the use of chemical additives. Actually, the quality and sanitary characteristics of our foods have been improving. Likewise, there is no evidence that consumption of foods resulting from the use of the new materials in crop production or in the production and processing of foods has created mysterious disease epidemics or endangered the health of people. It is to the credit of industrial concerns and law-enforcing agencies that they have been able to make so much progress in industrial production without jeopardizing the health of the public.

The complexity of the problems of the food industry combined with its responsibility to the consumer and the government makes it incumbent on the food industry to cooperate with the Food and Drug Administration officials in working out the problems facing industry and the consumer. As has been said on another occasion *(12)*, "Industries and government agencies are faced with a group of problems focusing on the common objectives of insuring adequate and wholesome food within the complex evolution taking place in agriculture, chemistry, medical sciences and the food industry. The industry has kept in view the serious consequences of introducing new and untried chemicals. However, no single agency, governmental, industrial, or medical, can anticipate all the results which may follow the introduction of a new chemical."

The organization of the scientific personnel of the food industry for the purpose of studying the problem of chemicals in foods, and advising management in connection with progress in research, governmental needs, and the scope of and ramifications of this problem, has not been very comprehensive. Technical committees representing segments of the food industry can be very helpful to management and should be able to study and discuss the various scientific developments that occur, thereby enabling management to formulate policies on an industry basis. These committees have also an important place in public relations.

Effective cooperation by means of technical committees of industrial groups having common interests, such as the Grocery Manufacturers' Association, would accelerate progress. These technical groups working closely with management could be exceedingly helpful in cooperating with the Food and Drug Administration and the Food Protection Committee. The Committee on Chemicals in Foods of the Institute of Food Technologists provides a platform for bringing together these technical committees.

The food technologist faces greater and ever expanding responsibilities as the food industry develops new methods and new processes based on modern requirements. As the adviser of management on processing procedures, he must clarify the practices of the food industry for the benefit of the public and for the government agencies.

As technologists and scientists we are interested in improving foods. We wish to promote ever greater application of science to the food industry. We seek to produce more nutritious, more acceptable foods. We should not permit ourselves to be diverted from these basic principles by use of chemicals of doubtful value from the utility standpoint, or of questionable safety from the standpoint of health. We should continue our scientific progress, bearing in mind that the interest of the consumer is our primary consideration.

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Process for Canning White Rice[a]

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A process for preparing a high-quality canned white rice has been developed. The product is made by soaking the raw grain, boiling until the moisture content is about 55%, canning under high vacuum, and retorting. The raw material for this process is white rice instead of the parboiled rice used currently for commercially canned rice products. The desirable brilliant white color and typical rice flavor are retained. The grains remain well separated and do not become distorted or mushy in appearance. The canned rice is prepared for serving by heating in boiling water for only one minute, whereas 20 to 40 minutes are required to cook dry rice by the usual household methods.

The average annual domestic consumption of all varieties of white rice is about 6 pounds of dry rice per person. Although the consumption of rice is comparatively low, its use is widespread. A recent survey *(3)* indicated that about 90% of United States homemakers were using rice. The infrequent use of rice in this country is most likely a result of the difficulties experienced by many housewives in preparing it, or possibly because of established eating habits. Still another objection to the routine use of rice is the time required to prepare it for serving, which ranges from about 20 to 40 minutes. Because a reduction in cooking time is generally considered at least one promising way to increase domestic consumption of rice, the development of easily prepared rice products has received considerable attention in recent years. The major items in this category are canned rice *(4, 5, 8)*, dried precooked rice *(1, 6, 7)* and frozen precooked rice *(2)*. In the past, the canning of white rice has presented a variety of problems. A principal difficulty has been the partial breakdown of structure and formation of a congealed mass of pasty grains when the canned rice was retorted. For this reason, canners have used parboiled rice, which yields a product with good separation of grains. However, canned parboiled rice lacks some of the qualities usually desired in freshly cooked white rice, namely a brilliant white color and typical rice flavor. As far as the present investigators know, there have been no prior developments of a commercially satisfactory canned white rice and none is now being marketed.

The main objective of the present investigation was to prepare a canned rice having all the desirable characteristics generally demanded in freshly cooked white rice. In judging cooked rice, the separation of grains is normally considered of prime importance. In addition, the color, texture, flavor, and general appearance of the product must be satisfactory. Prior art and preliminary canning tests at this Laboratory yielded a congealed mass of distorted pasty rice grains. The obvious procedure of simply packing fully cooked rice into cans, sealing and retorting, resulted in this same undesirable product. High moisture content in the rice or the presence of excess liquid in the can before retorting was found to be primarily responsible for the stickiness and clumping effect. Therefore, it was considered advisable to limit the moisture absorbed by the rice and to complete the hydration before packing into cans so that the moisture would be evenly distributed.

EXPERIMENTAL PROCEDURE

The general problems which were investigated included the details of hydration procedure, the desirable limits of moisture content, type of container, and method of closure. The material used was raw white rice, which normally contains about 10 to

[a] A report of work done under the Research and Marketing Act of 1946.
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14% moisture. Any of the known varieties is probably satisfactory, whether of the long- or short-grain type. The 2 varieties used were short-grain California Pearl, which is soft and porous, and the long-grain Texas Patna, which is comparatively hard and vitreous. It was considered that these two would reasonably represent the extremes of physical properties, particularly the characteristics of moisture absorption and texture, and that other varieties would be intermediate.

Soaking. The rice was washed with cold water to remove free starch, dust, and other extraneous material, and then soaked for about 30 to 45 minutes, depending on the variety used. When raw white rice is soaked in water below its gelatinization temperature, it reaches an equilibrium moisture level of about 30%. Preliminary tests showed that Pearl rice reached the equilibrium moisture level in about 30 minutes when soaked at about 80° F. (27° C.) and that Patna required about 45 minutes under the same conditions. The final moisture content of rice soaked at 131° F. (55° C.) was no higher than at 80° F., although the rate of imbibition in the first 10 to 15 minutes was greater. Furthermore, the time required to reach equilibrium was about the same at both temperatures. Although it is possible to prepare canned rice without pre-soaking, the results have not been entirely satisfactory.

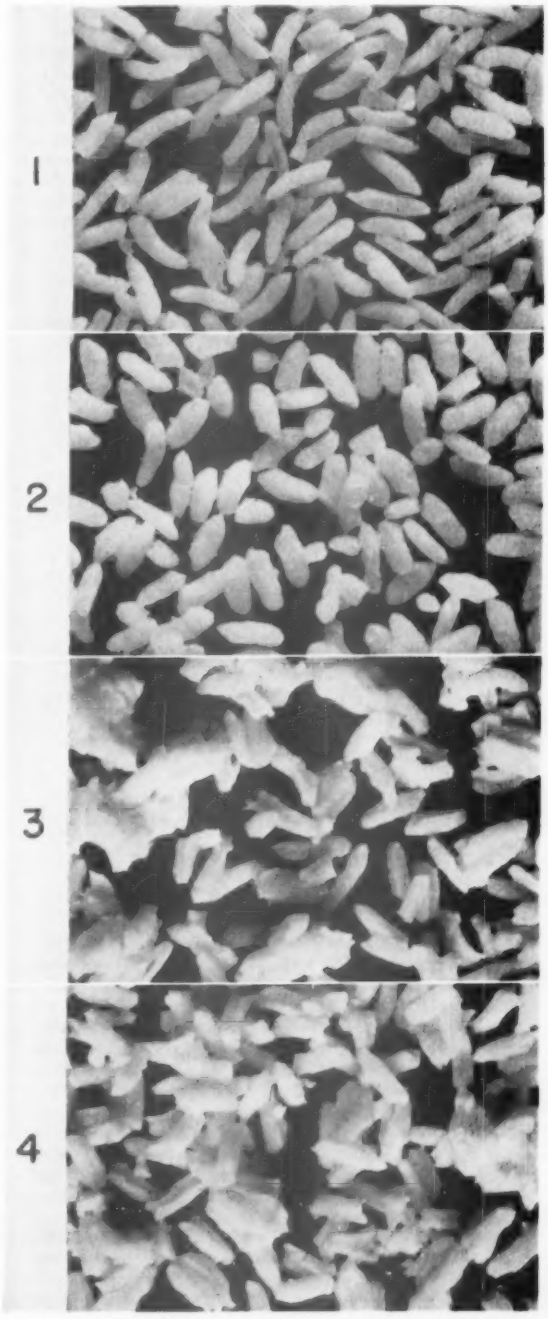
Boiling. After soaking, the rice was boiled in water for a period of one to 5 minutes. During this treatment the rice was partially cooked and the moisture content increased to about 45 to 60%. Changes in moisture content within this range affected the texture and grain separation of the rice to some extent but had little influence on the color or flavor of the finished product. It was found advisable to keep the moisture content below 60%, because under these conditions the rice did not become sticky and the grains remained nicely separated.

The time required to prepare the canned rice for serving, by heating in boiling water, was found to vary inversely with the moisture content of the product. Thus, the cooking time could be varied from about 30 seconds to 5 minutes by proper adjustment of moisture. However, a preparation time of one minute was arbitrarily chosen and the moisture content of the canned rice was adjusted accordingly. The increase in moisture content of the rice during the boiling step was related both to the boiling time and the variety of rice being processed. The optimum boiling time for pre-soaked Pearl and Patna which would satisfy the established requirements was about 2 and 4 minutes, respectively. Under these conditions, a moisture content of about 55% was obtained for both varieties.

Effect of pH. The effect of pH was investigated in an attempt to improve further the quality of the canned rice. It was previously known that alkaline solutions produced a yellow color in white rice and were purposely avoided. Addition of acid to the boiling water was found to be of little value in increasing the quality of the canned rice, with the exception of low concentrations of acetic acid. In fact, adverse effects were observed when citric acid was used. The product lost the typical rice flavor almost completely and became tough or rubbery when boiled in 0.01 to 0.1% citric acid solutions. When 0.1% acetic acid was used, it imparted a typical acidic odor and flavor to the rice. However, a concentration of 0.01% or less did not give this undesirable effect and slightly improved the color and flavor. The pH of tap water may commonly be as high as 9 to 9.5 in some areas. In such cases, it would probably be advisable to adjust the pH to 7 or slightly below with acetic acid. A concentration of 0.005% is satisfactory for this purpose. This is equivalent to about one drop of glacial acetic acid per liter of tap water or about one-half ounce per 100 gallons.

Closure details and retorting. After the soaked rice was boiled in water for the appropriate time, it was put into cans, sealed under high vacuum, and retorted. The use of C-enamel cans was considered mandatory, because the objectionable odor of free hydrogen sulfide was readily detectable when samples of rice packed and processed in other types of containers were opened. Furthermore, if a vacuum of 26 inches of mercury or less was used, the rice acquired a light brown color and an objectionable odor and flavor. Little, if any, improvement was obtained by replacing the air in the cans with nitrogen. However, when the rice was packed in C-enamel cans and sealed at 28 inches of vacuum, the product remained very white after processing and had an excellent texture, flavor, and separation of grains.

A heat penetration study on long-grain rice in 300 × 407 cans (the size commonly used for canning rice commercially) prepared as described above was made by the National Canners Association Research Laboratories, Western Branch. A process of 55 minutes at 240° F. (115.6° C.) with an initial temperature of 70° F. (21° C.) was recommended for this can size when



Effect of processing conditions on the appearance of canned rice. 1. Texas Patna canned according to the suggested procedure. 2. California Pearl prepared similarly. 3. Patna thoroughly cooked before canning. 4. Patna boiled in excess water for 10 minutes prior to canning. Approx. 1⅓ magn.

closed under at least 23 inches of vacuum. However, additional heat penetration studies would be advisable before commercial packs are made.

Most of the rice canned at the Western Regional Laboratory for experimental purposes was packed in 211 × 300 cans and processed 60 minutes at 240° F. (115.6° C.), which was considered more than adequate. Heating at this temperature for a period as long as 2 hours did not adversely affect the texture of the rice or the grain separation, although a very slight color development was observed when the rice was heated for the full 2 hours.

Appraisal. When the product was considered satisfactory from nearly all standpoints, samples were submitted to an experienced taste panel for appraisal. The canned Patna was compared with freshly cooked white rice from the same batch of raw grain, and 2 commercial brands of canned long-grain parboiled rice. The canned Pearl was compared with freshly cooked raw rice only, because commercially canned short-grain rice was not available. The results of this study are shown in Table 1. Appraisal scores of the canned rice after storage at room temperature are shown in Table 2 and are compared with those of freshly cooked rice. Samples were judged for each characteristic on a scale ranging from 7 for the highest score to 1 for the lowest. The appraisal data shown in the tables were obtained by averaging the scores of at least 9 judges from 3 replications of the test.

TABLE 1
Comparison of canned samples, freshly cooked rice, and commercially canned products

	Separation of grains	Color	Flavor	Texture
Canned Patna	6.4	6.6	5.9	6.2
Fresh Patna	5.0	6.8	6.4	5.7
Commercial Sample A	6.5	4.2	5.0	5.6
Commercial Sample B	6.0	4.5	5.5	5.6
Least significant difference at 1% level	0.6	0.4	0.3	Not sig.
Canned Pearl	6.2	6.0	5.9	5.9
Fresh Pearl	3.8	6.5	6.4	4.7
Least significant difference at 1% level	0.9	0.4	Not sig.	1.0

TABLE 2
Effect of 9 months' storage on the quality of canned rice

	Separation of grains	Color	Flavor	Texture
Canned Patna	6.6	6.8	5.7	6.1
Fresh Patna	6.0	5.4	6.1	5.2
Least significant difference at 1% level	0.5	0.5	Not sig.	0.6
Canned Pearl	6.0	5.8	5.7	5.8
Fresh Pearl	4.2	6.5	6.1	4.4
Least significant difference at 1% level	0.6	0.4	Not sig.	0.8

The appraisal data in Table 1 show that the canned Patna was judged better than the fresh rice and equal to the commercial products in separation of grains. It also had a much lighter color than the commercial samples, as good as or possibly better texture than the other 3 samples, and a flavor score better than commercial but slightly lower than the freshly cooked rice. The most interesting factors concerning the canned Pearl were the greatly improved grain separation and its better texture, although the flavor differences were not significant and the color score was slightly lower.

A comparison of the data in Tables 1 and 2 shows that the canned white rice compares favorably with freshly cooked rice and that no deterioration occurred during storage at room temperature for the period indicated. In both taste tests, the scores on separation of grains for the canned white rice were significantly higher than those for the freshly cooked rice. Differences in flavor scores between the stored canned rice and freshly cooked rice were not significant at the 1% level.

DISCUSSION

The process described herein was developed on a laboratory scale for the purpose of overcoming inherent difficulties in canning white rice. Although production problems were not investigated, no difficulties in handling commercial quantities are foreseen. Rather simple equipment is required. Containers for soaking and boiling the rice are all that is necessary, except for conventional packing and sealing equipment. The suggested process consists of the following steps:

1. Wash and soak the raw white rice in cold water for a period of 30 to 45 minutes, depending on the variety used.
2. Boil the soaked rice in water for about 2 to 4 minutes, depending on variety, or until the moisture content has increased to about 55%.
3. Pack the partially cooked rice in C-enamel cans and seal at 28 inches of vacuum.
4. Retort for the proper length of time (based on heat-penetration studies for the can size used and packing conditions) to insure commercial sterility.

The proportions of rice to water used during the boiling step and the rate of heating, as well as the time of boiling, will affect the moisture content of the canned product to some extent. Therefore, test runs would be advisable before large quantities are processed.

The rice can be prepared for serving by either of two methods: a, add the contents of a 300 × 407 can to about a quart of boiling salted water, stir slightly, and drain in a collander; or b, add to a half cup of boiling salted water, stir gently until all of the moisture has been absorbed by the rice. Prepared in this manner, the canned rice is comparable to best -quality freshly cooked rice. In fact, in separation of grains, the canned product is superior to freshly prepared white rice and equal to parboiled rice. Furthermore, it offers 2 principal advantages to the consumer—first, that the rice can be quickly prepared for serving and second, that little culinary skill is required as compared with raw white rice.

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Maple Sirup. VI. The Sterilizing Effect of Sunlight on Maple Sap Collected in a Transparent Plastic Bag

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The sterilizing power of sunlight in reducing the bacterial content of maple sap when exposed in plastic bags (transparent in the ultraviolet region) is described. Evidence was obtained that under the conditions of this experiment maple sap became practically sterile upon exposure to bright sunlight during cool weather.

As part of the program to isolate spoilage bacteria from maple sap, plastic maple sap bags were used for collecting the sap. Contrary to expectations the sap so collected was practically sterile. Although the sap contained traces of extraneous material including insects and bits of bark yet a plate count showed less than one bacterium per milliliter, indicating that the plastic bags were producing a sterilizing effect. This was of special interest since the maple industry has been much concerned with developing means of preventing contamination of the sap with microorganisms and reducing spoilage.

Edson, Jones and Carpenter in 1912 *(3)* in an extensive study of the bacteriology of maple sap showed that sap became contaminated by adventitious bacteria common in nature and that growth of these organisms in sap resulted in a poor quality, dark sirup—often with off-flavors. These results were confirmed by Hayward and Pederson *(5)*. However, no means was developed for controlling the contamination of the sap in the sugar bush or for preventing growth in storage tanks. Willits *(12)* and Holgate *(6)* evaluated the efficacy of many disinfectants for controlling microorganisms in maple sap but found objections to all. Either they constituted health hazards or impaired the quality of the sirup. Sirup prepared from sap collected in plastic bags was of exceptionally high quality and flavor, even though it had remained in the bag for as long as 2 weeks and at temperatures of 32° to 70°F. (0° to 21° C.). There were two possible explanations for the sterilizing power of the plastic bags. Either it was due to the presence of a bactericidal chemical in the plastic or to the sterilizing effect of ultraviolet rays in sunlight. Experiments were performed to test these hypotheses and the results indicate that the disinfecting action is due to sunlight.

EXPERIMENTAL

The bags used in this study were of Vinylite plastic, presumed to contain plasticizer and stabilizer, and are commercially available for the collection of maple sap. These bags were first rinsed with two liter-portions of boiling sterile water to remove the greatest number of extraneous bacteria. Into each bag was placed one gallon of sterile sap collected asceptically according to the technique of Holgate *(6)*. The bags were then inoculated with a bacterial culture isolated from maple sap which had spoiled when stored in a refrigerator room at 34° to 37° F. (1.2° to 2.8° C.). The bags were then exposed to outdoor sunlight by hanging onto a tree trunk. As controls, similarly filled bags were placed in covered metal cans also hung on a tree. A record of the sap temperature was made using a recording thermometer. Hourly readings were observed from the recordings and the average daily temperature calculated. Values for percent of sunshine were obtained through the courtesy of the U. S. Weather Bureau, Philadelphia, Pennsylvania.

Bacterial numbers in the original sap and in that held in the bags were determined by plating on nutrient agar after making appropriate dilutions to give 30 to 250 bacterial colonies per plate. The plates were incubated at room temperature for 2 days before counting. Although the culture was isolated from sap stored at 34 to 37° F., it was able to grow more rapidly at room temperature, making it possible to count the plates in 2 days.

RESULTS

In the initial experiment, sterile fresh maple sap was inoculated with approximately 3,000 bacteria per ml. and the bags were fastened to a tree in a southerly exposure. One day later a similar experiment, but in which the sap was inoculated with approximately 250,000 bacteria per ml., was set up to determine whether the sterilizing effect would be operative in the presence of large numbers of bacteria. The results presented in Table 1

TABLE 1

The bacterial content of maple sap inoculated with approximately 3,000 and 250,000 bacteria per ml. and exposed to sunlight in plastic bags

Date	Amt. of sunshine	Inoculum, Approx. 3,000/ml.		Inoculum, Approx. 250,000/ml.	
		Exposed	Not exposed	Exposed	Not exposed
1952	% of day	*Bacteria/ml.*	*Bacteria/ml.*	*Bacteria/ml.*	*Bacteria/ml.*
2/25	—	3,300[b]	2,900[b]		
2/25	65	3,100[c]	3,300[c]		
2/26				208,000[b]	261,000[b]
2/26	81	2,400	3,400	212,000[c]	337,000[c]
2/27	73	2	8,500	142,000	343,000
2/28	92	1	44,000	230	2,200,000
2/29	63	0	66,000	27	2,100,000
3/1	32	[d]	—	—	—
3/2	70	0	4,240,000	0	18,500,000
3/3	0	—	—	—	—
3/4	0	0	7,200,000	9	20,000,000

[b] Immediately after inoculation.
[c] Exposed only half day.
[d] — indicates bacterial count not determined.

show that in both experiments the bacterial count was reduced to zero in the bags exposed to the sun but had increased to several million in the bags protected from sunlight by inclosure in the metal cans. These experiments demonstrate that the sun's rays transmitted by the plastic bags were not only bacteriostatic but also bactericidal.

To determine whether this sterilizing effect was limited to the action of direct sunlight, a third experiment was performed in which bags were hung about a tree exposing them to the 4 cardinal points of the compass. The results, presented in Table 2, show that all exposures (at the time of these experiments, February and March) were effective in reducing bacterial numbers but the sunny exposures (southerly and westerly) were more effective than the locations in which the bags were in the shadow of the tree most of the time (northerly and easterly). During the first few days of these experiments the weather was rather cloudy and warm with rain, with the result that the bacterial count showed a steady increase. Even so, the increase in bacterial count of the sap in the exposed bags was less rapid than in the bag which was not exposed to sunlight. This initial period was followed by 5 days of sunny and colder weather and

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the bacterial counts of the sap in the exposed bags dropped sharply, the sap becoming almost sterile in the one hung on the sunny side of the tree. This weather condition was followed by 3 warm, rainy days with no sunshine and the bacterial count again increased. This would indicate that during such exceptional periods at the end of the sap season when the weather is cloudy and warm for long periods, the sap cannot be allowed to stand in the bags if a product low in bacteria is to be obtained. However, even after this increase, the bacterial count of the sap in the exposed bags was only 1 to 10% of that in the bag not exposed to sunlight.

Since all of these experiments were conducted on artificially inoculated sap, it was desirable to determine whether sap originating from a naturally contaminated sap hole could be sterilized by collecting in a plastic bag. The sap flowing from such a contaminated hole was divided; one-half was allowed to flow into a plastic bag and the other half into a covered metal sap bucket. The sap flowing from the spile had 860 bacteria per ml. After 7 days (March 25 to March 31) the sap was collected and the bacterial counts determined. The sap in the plastic bag was clear and had only 3,100 bacteria per ml. while that in the sap bucket was milky and had 144,000,000 bacteria per ml. Samples of sap from the exposed bag and from the bucket were transferred to glass jars and photographed against a dark background (Figure 1) to show the milkiness developed in the sap collected in the sap bucket.

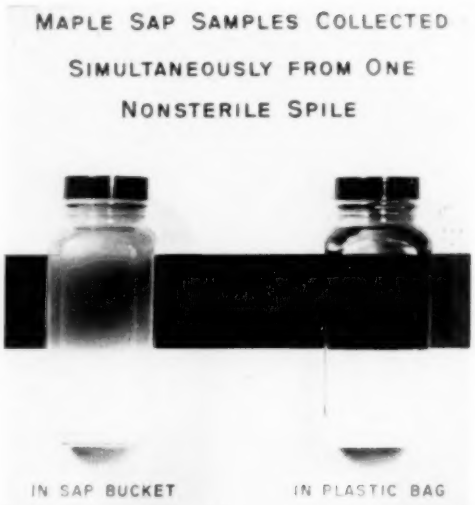

Figure 1. Effect of collecting sap from a contaminated sap hole in metal sap bucket and plastic bag on the growth of bacteria.

DISCUSSION

The decrease of bacterial numbers in the sap exposed in the plastic bags was undoubtedly the result of the sterilizing effect of the sun's radiation. The lethal action of sunlight on certain bacteria was demonstrated by Downes and Blunt as early as 1877 *(2)*, and since then the effects of ultraviolet radiation on microorganisms have been studied frequently. The older literature has been reviewed by Ellis and Wells *(4)*. The region of bactericidal activity has been reported to lie in the region of wavelengths shorter than 3000 A, the most effective being near 2600 A. Studies of the energy distribution of the solar ultraviolet radiation reaching the earth have been limited by availability of proper instruments. The measurements made by Pettit *(8)* and Stair *(10)* are probably the more exact, and place the short wavelength limit between 2900 and 3000 A. This short wavelength limit is known to vary with the latitude, season, and time of day. This means that the amount of radiation present in sunlight in the region of germicidal activity is only a small and variable fraction of the total ultraviolet component.

A spectral transmission curve of the plastic from bags used in these experiments is shown in Figure 2 (curve I). The plastic transmits from 50 to 80% of the radiation longer than 3100 A with a rather sharp cut-off in the region of 2900 to 3000 A, which coincides with the established limits for the solar ultraviolet. Precautions were taken, in these transmission measurements, to reduce light scattering by the plastic to a minimum by coating the plastic with glycerin and sandwiching between quartz plates. This effect could not be corrected completely, however, and the effective transmission may be somewhat higher than shown. Luckiesh *et al. (7)* have determined the relative bactericidal effectiveness of radiation from 2200 to 7000 A in wavelength. Values taken from their curve are plotted in Figure 2 (curve II). It can be seen that the germicidal efficiency of radiation in the region transmitted by the bag is relatively poor (cross-hatched area); nevertheless, over the long period of exposure encountered in these experiments sufficient energy is transmitted to cause the desired germicidal effect.

TABLE 2

Bacterial growth in maple sap as a function of exposure in plastic bags at four locations on the tree

Date	Amt. of sunshine	Ave. temp.	Exposure				
			Northerly	Easterly	Southerly	Westerly	Not exposed
March 1952	%	°F.	*Bacteria/ml.*	*Bacteria/ml.*	*Bacteria/ml.*	*Bacteria/ml.*	*Bacteria/ml.*
9	15*	40	700	1,000	600	500	500
10	42	48	1,900	1,800	1,800	1,500	3,000
11	10	47	47,000	54,000	58,000	46,000	360,000
12	100	44	1,200,000	900,000	157,000	108,000	8,900,000
13	26	38	1,700,000	910,000	60,000	24,000	14,000,000
14	100	39.5	2,020,000	750,000	5,200	13,600	18,700,000
15	100	39	260,000	260,000	7,600	1,600	17,000,000
16	62	34	—†	—	—	—	—
17	87	47	136,000	17,000	800	200	26,000,000
18	91	45	53,000	<100	200	20	39,000,000
19	0	40.5	—	—	—	—	—
20	93	55	31,000	7,000	3,000	60	60,000,000
21	54	58	640,000	327,000	2,600	10	44,000,000
22	0	42	3,900,000	1,500,000	19,300	2,900	53,000,000
23	0	41.5	—	—	—	—	—
24	0	41	4,900,000	3,800,000	870,000	90,000	59,000,000
25	100	50	—	—	—	—	—
26	96	50.6	5,700,000	6,800,000	1,300,000	110,000	73,000,000

* Corrected for only one-half day exposure.
† — indicates bacterial count not determined.

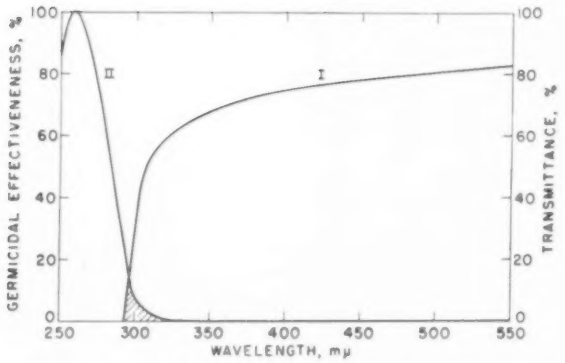

Figure 2. I. Spectral transmittance of sheet (0.012 inch thick) cut from plastic bag, with scattering reduced by sandwiching between quartz plates moistened with glycerin. II. Relative germicidal effectiveness of radiant energy (after Luckiesh et al [7]).

Rentschler *et al. (9)* and Luckiesh *et al. (7)* while reinvestigating the Bunsen-Roscoe reciprocity law noted that low intensities of germicidal energy are effective if permitted to act over a long time. The sensitivity of the microorganisms was found to vary at different stages of the growth cycle, the more rapidly growing organisms being more susceptible. Evidence was also obtained that sub-lethal doses of irradiation greatly retarded the development of the organisms. This is in agreement with the results of Coblentz and Fulton *(1)* who found that germicidal action of radiation was cumulative, and that an intermittent exposure had the same effect as a continuous exposure for an equivalent length of time. Examination of results in Table 1 reveals that almost 2 days' irradiation was required before a pronounced drop in bacterial count was obtained in the sap. It should be recognized that during these prolonged periods of exposure which extend over several generation times, growth as well as destruction of bacteria are occurring simultaneously, and the bacterial count at any given time depends on which process was favored by the climatic conditions such as temperature and intensity of radiation. Thus during warm, cloudy weather the bacteria will grow faster than they are killed and the bacterial count will increase, but even so the apparent growth rate will be considerably less than if the sap were not exposed to daylight. During cool sunny weather the bactericidal effect of the sunlight will be more pronounced and the bacterial count will decrease. Of course there will be times when growth and destruction will occur at equal rates and the bacterial count will appear to be stationary.

Although Luckiesh *et al. (7)* found that radiation of wavelengths longer than 3000 A was relatively ineffective, yet the possibility exists that it may also exert appreciable influence when long exposures are used. Swart-Füchtbauer and Rippel-Balden *(11)* recently investigated the bactericidal activity of sunlight and found an appreciable effect even in the visible region at exposures of 12 to 16 hours. By exposing maple sap in plastic bags we are making use of a property of sunlight which has not been sufficiently appreciated and which as yet is not thoroughly understood. Although the experiments presented here demonstrate the sterilizing power of sunlight, it must be kept in mind that the results were obtained with only one type of micro-organism in the controlled experiments, and during only one season. However, the sterilizing effect was demonstrated with sap contaminated by natural flora during the normal period of maple sap collection.

In recent years, there has been a definite increase in consumer demands for the lighter grades of maple sirup. An important factor in the production of this light grade sirup is delivering to the evaporator only sap that is free of microbial spoilage. The use of plastic bags or other containers transparent to sunlight, together with improved sanitary practices, should reduce microbial growth and help increase the production of the desired higher quality maple sirup.

SUMMARY

The sterilizing power of sunlight was found to be effective in reducing the bacterial content of maple sap when exposed in plastic bags, transparent in the ultraviolet region.

Both artificially inoculated and naturally contaminated maple sap became practically sterile upon exposure to bright sunlight during cool weather.

Evidence was obtained that in exposed bags the growth and destruction of bacteria occur simultaneously and that the predominance of one process over the other is dependent on such factors as temperature, intensity of radiation and time of exposure.

Acknowledgment

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Increasing Population and Food Trends

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The population of the United States has been growing faster than nearly anyone expected a dozen years ago. In the 1930's experts expected a stable population of around 175 million to be reached about 1980. Sometimes the estimate was as low as 165 million. Today we number about 156 million, which is about 10 million more than we were expected to have in 1952.

Birth rates have increased instead of declining, death rates have been further reduced, and immigration from other countries has totaled a million in the last three years rather than a few thousands as predicted by those studying in the dark days of 1933-38. Between 1940 and 1950 the increase in U. S. population was something over 19 million people. The higher level of incomes possible with full employment apparently has been a major factor in the increase. People are less likely to defer marriage and restrict the number of children under buoyant economic conditions. Compare the characteristics of the college students of the 1950's with those of the 1930's.

It is now clear that the prediction of the future course of population is about as difficult as to forecast the price level for 1970 or 1980. Nevertheless, it is clear that short of a catastrophe greater than World War II the year 2000 will see a population of well over 200 million, possibly between 225 and 250 millions of people. The changes that this increase will effect in school systems, housing, medical and dental facilities in cities and towns all over the nation will be many and substantial. Shortly, these changes will be related to trends in the production of food, but first a few words about changes in other areas.

Population Trends Outside the United States

Population changes in Canada are much like the United States with perhaps a relatively greater immigration from Europe. In Western Europe population changes have been much smaller. But even so, during the 1940-50 period and despite the war losses, population increased by over 15 million people. Even in France where the population was stable or declining before the war, the birthrate has increased from 15 per thousand to over 20 per thousand and total population is increasing. In eastern Europe and the Soviet Union the rate of population increase has been greater than in western Europe.

Turning last to South and Southeast Asia and other underdeveloped areas, population continues to expand despite the poverty of its people. In these areas the potentialities for increase are great if food and medical knowledge can be made available to save a larger proportion of the children and reduce the disease and malnutrition affecting those who live through the first year.

Food Production in the United States

The next task is to summarize equally briefly the trends in food production. Substantial increases in food production have occurred in the U. S. in the last fifteen years. The increase amounted to about one-third and was accomplished with somewhat better than average weather, but with serious handicaps such as a million less agricultural workers and some difficulties in obtaining all the capital equipment which was desired. Not only have the people of the U. S. eaten better than ever before, but exports were stepped up to provide food supplies to western Europe and to certain parts of Asia.

Part of the expansion in food production was made possible by the continued release of acreage from horse feed to human food as tractors became the major source of power. But more of it is due to the results of agricultural science. We have more than doubled the use of fertilizer, and we are using it more efficiently. New and more productive varieties of crops such as hybrid corn, new rust resistant wheats, etc. have helped increase crop yields. More effective chemical sprays for insects and the new weed killers have saved more of the crop and reduced competition with weeds and pests. Continued selection of better strains of livestock, artificial insemination and the great strides in animal nutrition have all contributed a part to the expansion of food production. This is why some of us say that much of what we now eat is literally the production of the scientific laboratories of this country.

Food Production in Other Areas

Agricultural production in western Europe has increased a third in the last three years. It has now reached and surpassed the pre-war levels of production by about 9%. Progress has been slower in eastern Europe, so that for Europe as a whole the level is not quite the 1934-38 average. Further increases are desired in Western Europe so as to reduce needed imports from the dollar area and to avoid depending upon satellite countries. There agricultural science is drawing heavily upon developments in the U. S. and Canada and adapting new science to their conditions. Educational programs through something similar to our Agricultural Extension Service are being developed or expanded. But of necessity the first efforts were to restore ariculture to its pre-war functioning. Now more effort can be given to improving productivity.

In the Far East food production is still slightly below the prewar level. A few countries such as Japan had good or record harvests in the past year. Other areas, as India, have suffered from acute food shortages. Per capita levels have, of course, generally declined since there is a larger population to share the smaller food supplies.

In the Near-East, Africa and Latin America, crop production is about 20% larger than in 1934-38. There were much smaller or at least no serious disturbances to agricultural activities due to military operations, and so expansion continued fairly steadily during the war decade. Much of the expansion comes from new lands made available through irrigation, roads, etc. Nevertheless, population expansion has continued apace and in some areas has increased more rapidly than food production, with resulting declines in per capita availability compared with prewar.

Canada, New Zealand, and Australia have expanded food production in ways similar to the U. S. But the increasing domestic population is reducing the ability to export. More and more of the food is being required for the home market. This brings us to the final section of this paper. Can agricultural production be expanded so that the next generation in North America can eat as well as the present generation? Can European countries find food supplies at home or in export markets to maintain their levels of consumption? Are changes in prospect for the areas where population could increase rapidly which would lessen the dependence of population on food?

SOURCES OF ADDITIONAL FOOD SUPPLIES

Again beginning with the U. S., scientific progress has not ceased to operate. There are relatively few acres left, however, which can be used for human food by disposing of horses. On the other hand, we are told that fertilizer use can probably be doubled again. The new sprays which control plant growth can contribute much to producing and saving food once produced. Further advances in animal nutrition are being tried out. Artificial insemination will operate for many years to improve the productivity of our dairy cows. And there are many farmers who are not yet using the knowledge and techniques employed by the most efficient farmers. The wider use of present knowledge will contribute a great deal in expanding food production. It may be necessary to make some shifts in diets. For example, per capita consumption of beef in 1975 may be lower and of pork higher because of the greater technical advances in pork production compared with beef production. But, as a whole, there is reason to be optimistic regarding North America.

For Europe the picture is more critical. Production of food can and will be increased, but an adequate diet by European standards will require food supplies from other areas. Moreover, the economy as a whole also requires a large amount of outside raw materials for its industrial processing. This means that Europe must have a large volume of export trade to pay for its imports. And the competition with the larger populations of North America, Argentina, and Australia will drive prices higher, barring a major depression. Buying from Russian dominated areas is politically undesirable and may also be difficult because the Russian area is also undergoing rapid increases in population.

It appears that Europe's ability to purchase supplemental supplies of food will depend upon two factors: (1) a willingness by other parts of the world, particularly the U. S., to purchase a considerable volume of industrial goods, thus letting Europe earn dollars to use for the purchase of food and raw materials. (An alternative is a permanent foreign aid program making dollars available as a gift.) (2) Increases in the application of agricultural and other science in other world areas which will expand the exportable supplies of food, textiles, minerals, petroleum products, etc. This latter point will now be further developed.

That part of the world now called under-developed is characterized by a pressure of population on food supplies, low per capita income and consumption, illiteracy, low productivity, high birth rates, and serious health and nutritional problems. The development and application of science is not a part of the cultural pattern, and there are wide differences in the distribution of income.

Many of our recent scientific discoveries can be very important in these areas. Insect and pest control, for example, are far more important in the tropics to both humans and animals than in the temperate zones where severe winters regularly reduce the insect population. The possibilities of plant breeding are much greater considering the yields of the varieties now grown. For example, simple selection has found coffee trees yielding 10 to 20 times the average of those now in production. The use of fertilizer in the leached out tropical soils should provide dramatic responses in yield, much greater, in fact, than on our relatively fertile mid-western soils.

The opportunities for scientific advances appear to be great. A major problem however, is to discover ways of reformulating the attitudes of the farmers so that they accept and use these new techniques as soon as they are developed. Traditional practices must be modified or completely abandoned and to induce agriculturists to do so is a difficult task. It is, of course, part of the job that is involved in the U. S. Point Four Activities and in similar programs sponsored by the United Nations and the Commonwealth Colombo Plan.

A second major problem is whether these modifications can be made fast enough to increase food production more rapidly than population. Otherwise there will be no gain in the internal situation and no increases in exportable supplies for Europe or other outside areas. It is doubtful if this can be done unless (1) deliberate attention is given to controlling the birth rate and (2) the movement to improve health conditions, particularly in regard to maternity and child care, is slowed down. Recent developments in India bear on the first point. National attention has been given to reducing the birth rate through employing a U. N. expert. Apparently, his efforts have been of considerable interest to people in widely scattered farms and villages.

SUMMARY

For the U. S. population increases will require larger amounts of food. Additional advances in science and farming efficiency offer the encouraging prospect of providing this food in the years ahead, although not necessarily in quite the same proportions as at present.

For Europe smaller population increases will also require additional food. Some will be available from increases in local production, but imports of food products will be needed. Europe's ability to export and thus pay for imports, will be a major factor affecting food availability.

In the under-developed areas rather major changes will be needed in organization and operation of production. Changes in the economic, social, and political institutions of these areas must occur so as to slow down population increase and speed up the adoption of more efficient processes. Otherwise, even the present low levels of living will be difficult to maintain and famines, unrest, and revolution are likely to continue.

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The Development of New Food Products[a]

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More new food products are in the offing. They stand in all stages of development in the food research laboratories, and in a number of them large sums have been invested. Their backers know from the record that the outcome is highly speculative. Even with all the latest technical and economic investigation methods, pilot and consumer panels and trial marketing, the issue remains speculative until full-scale public acceptance has been established. The appearance of each new aspirant is watched with the thrill of a grand lottery by those who know the hazards and appreciate the size of the stake for the few that succeed each year.

Factors that led to the important new food products of the recent past still exist, and some new ones have become apparent. Each advance in nutritional knowledge is a threat to the balance of power in the food markets, and a promise to the more progressive food industries. Improvements in transportation, in food handling and storage, and in packaging materials—paper, glass, tin, plastic—are all opening new possibilities. Home equipment advances, refrigerators, freezers, special cooking facilities, all have their repercussions in new food possibilities. The market for baby foods has become enormous within a very few years. The business grew 1700% in the last 10 years, and is expected to double again in the next five. It is probable that other specialized areas will in time be met with special products—special military food products, for example. Foods especially suited for old people may be expected. Unfortunately, the best means for increasing the life span suggested by nutritionists is to avoid over-feeding during the growing period and, since few growing children worry about longevity, special products for this particular market may be delayed a bit. Studies on the relation of nutrition to the life span continue, however, at Cornell and elsewhere, and publications in the future may change the situation significantly.

A peep over the horizon to one or two of the more distant prospects was furnished us during the past year or two. The economic possibility of growing algae as a food was explored in a preliminary way. With some increase in yield or specially favorable conditions it is a possibility. Yeasts based on by-products or waste products, including wood, are being examined. New plant varieties—as the special hybrid corn to give desired properties in the starch—may have possibilities. We are told that possible by-products from fish waste are discarded; some 6% of fish fileted in the new floating processing plant is now returned to the sea as waste. Oceanographers claim the sea is a great and a greatly neglected source for new foods for increasing populations, and they cite chapter and verse for their claims.

The more obvious new areas are still comparatively unexplored. Freezing of cooked meals is in an embryonic stage. Sterilization by high voltage electron bombardment offers promise of new treatments, new commercial approaches. The live preservation—live packing—of lobsters has been tried experimentally. Currently we are reaching new heights in the art and science of flavor research and flavor quality development and preservation. New products and improved products are bound to come from this new knowledge.

Perhaps most significant of the factors leading to more new food products is the continued increase in the amount of food research. The ratio of research expenditure to sales in the food industry has doubled since 1938, with 6400 food researchers in 1951 compared with 500 only twenty years ago. With many known projects underway, with nutritionists and marketing students continuing to supply information on which improvements can be based, with increasing food research, we are sure to see a continuing flow of new food products.

The development of new food products follows a pattern that is more or less standardized. It may be telescoped, and occasionally the several elements can be run in parallel, simultaneously. But omission or undue delay of any major element can cause great financial risk.

FINDING A NEW PRODUCT TO DEVELOP

The $64 question comes at the start—how do you find a new food product to develop? The record of successes does not give too obvious an answer. With many of the products the very earliest steps had already been accomplished when defined managerial procedures for appraisal and development could be put in motion. The product itself had been identified.

A dictum from top management to a research department, ordering the creation of a successful new food product, followed by the setting up of project "Number X241, New Product," is by itself no assurance that the company will market the new product four or five years later. The record shows that many of the significant new food products originated outside established food research organizations, and were brought within their orbit at various stages of development. Others developed within the food company, but were based on the creative imagination of an individual who brought the project to management for support, on his own initiative.

Clarence Birdseye's initiation of the frozen food industry is a spectacular example. His colorful story of pulling a fish into the deep cold of a Canadian winter, freezing it so rapidly it had no time to die, then finding it swimming when it thawed out is not the typical first page record of a research department notebook. Whatever the genesis of his project, he obtained support for early development, established pilot operations at Gloucester and had frozen many a food product when General Foods absorbed his work and launched the new industry. Frozen orange juice, that has made such an impact on its section of the food industry, was not a mere extension of the then frozen food industry. It came from outside, from the application of high vacuum technology originated by Hickman in the Eastman Kodak Laboratories and developed and applied by Richard

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Morse, initially to a powdered juice.[b] Meat as a baby food was envisioned by Harold Schultz at Swift, but not as the result of an assignment to find a new product. In part because his conception was within the environment of a well managed and supported research organization, he was able to carry through to full commercial operation in record time for a new food project of such novelty and significance—less than three years. Not until two years later did competition appear in his markets.

These examples constitute new approaches such as are not created on order. In some instances major modifications, resulting in new products and opening new markets, have been prescribed in advance by management, and carried to successful conclusion by food technologists and their associates.

An outstanding example is the development of a quick-cooking cereal. When it became apparent to the company management that kitchens were no longer populated by cooks that worked their twelve hours a day but principally by housewives who had other duties or preferred bridge, they saw the need of meeting the convenience of ready-cooked cereals while retaining the character, digestibility and other advantages of their well-established product.

The basic specifications of the present successful product were defined in advance. They were disarmingly simple—make it cook while the cook is putting the cereal dishes on the table, and make it a better product—but don't change it. The assignment was given a consulting laboratory that expressed some doubt about the probability of complete success, but with an invention and a bit of imaginative research the first quick-cooking hot cereal was produced—one of the very first, if not the first, vitamin and mineral fortified general household food products. It was but a short time before it outsold its parent product.

The success of frozen orange juice has led to the creation of related products on order from management, by research and development methods known in advance. We have cranberry juice, apple juice, grape juice, lemonade and many others. Many of the pie, cookie and cake mixes and the like were developed on order by systematic organized research method. Shelf life has been increased to permit new marketing practices by anti-oxidants, by new packaging materials or methods. Most food product companies have a host of such opportunities available to them. But such improvements are on the border line or out of the field of distinctly new products. They offer less spectacular gain, but also involve far less hazard.

"Idea men,"—men of imagination, creative instinct, inventive capacity, perhaps not too inhibited by dull practical considerations—are still a major source of all significant new products. That company is fortunate that has one or more of them, and that company is wise that knows how to encourage, support and properly exploit them. Lacking such men, or even as supplementing them, organized means for locating and evaluating their projects is indicated.

If a company seriously needs a major new food product, and if its research department has the assignment, the oblique approach in the first instance may be effective. There is one industrial research word that has not been overworked. It has, rather, been neglected. And that is Willis R. Whitney's favored word—serendipity. Serendipity is the art of finding something while you are looking for something else. Columbus' discovery of America while he sought India is an example. The point, of course, is that if he hadn't been looking for an India he would have found nothing new. In other words, start looking for something, using all your knowledge, skill and ingenuity, but keep your eyes open for new things along the way, and be ready to identify and develop their values when they appear. There should be more serendipity and less methodical highly organized plodding in the early stages if radically new products are to be found by search.

Supplementing the internal approach, methods of prospecting for new products—edible and non-edible—have been well developed and practiced successfully. Many leading research staffs have technical-economic men whose business it is to make market surveys, seek and evaluate new projects, find the "sleeper" that can be exploited. Such work is an important part of the activity of the larger consulting research organizations and is available to industry generally.

[b] The Florida Citrus Commission holds a patent on the addition of small amounts of raw juice to the concentrate to improve flavor. Agricultural specialists cooperated in the work leading to this essential step.

APPRAISAL OF NEW PRODUCTS

Whether an embryonic new food product—a potential frozen food industry or even a new pie mix—is conceived by an idea man, created within the research laboratory, found by a new-product survey group, or brought to the company president at last night's cocktail party—it should be appraised by methods that are now rather well developed.

It should be thus appraised for various commercial and technical aspects almost continuously once it gets beyond the low cost, early bench research stage. Modern market surveys are made by staffs of trained personnel, and consumer market appraisal is an organized business. "Mother-in-law" surveys are still practiced, usually by top executives who tend by instinct to depend more on a little first-hand information or comment than on conclusions of specialists based on data carefully assembled, statistically sound and objectively evaluated. The "mother-in-law" survey resembles the recent search for water in Bermuda by passing a dowser over the map—it can be as deceptively alluring to the naive layman, as impossible to combat by logic or by objective findings—and as cruelly disappointing and wasteful.

Some of the sound appraisal methods have been described by Crocker, Sjöström and Tallman. They found that panel testing can be objective, with training. Incidentally, they noted that with choice of foods in reasonable abundance, appearance—color, odor, firmness, for example—is of great importance. The Research and Development Division of the Quartermaster Corps has experimented extensively with food acceptance, using panel testing and a semi-quantitative scale of values. Most large food companies have progressed far beyond the reputed practice of one of the most successful of soup companies, whose directors and top officers are said to have deferred their breakfasts until they could assemble for their morning's evaluation of whatever was cooking, or about to be cooked.

Too limited a scope in panel evaluation can be deceptive. An early development of a coffee flavoring met favorable preliminary market surveys and even trials in New England, only to find that the Chicago market, for example, did not recognize coffee as a flavor for ice cream or fountain beverages. A trial 5 gallons of coffee ice cream came back to the plant with one scoopful taken out by the curious retailer—and a report of no customer desire. Early marketing of nationally advertised coffees met resistance in areas accustomed to particular blends, even of inferior grades by coffee-tasters' standards. Yeast may be nutritious and palatable foods may be made from it, but West Indian islanders long accustomed to Nova Scotia's salt fish may not buy them. Heid noted that blackeyed beans sell in the south but not in New England. Diverse economies, habits and religious taboos are pertinent. A taste panel selected from Quartermaster Depot personnel and a squad confined for long periods to Army rations at a tough

forward post may give differing comments on consumer acceptance.

The food industry was second only to steel and automobiles in a recent estimate of outlay for replacement and modernization—amounts running up to the half billion mark. Such expenditures are not made blindly. Market surveys and consumer panels are followed by pilot operations. Armour & Co.'s pilot plants, for example, include those for fat refining, experimental baking, canning, meat curing and food, dairy and poultry products. Most new food ventures of any magnitude are preceded by pilot plant operation, often conducted in the speculative stage before management has decided whether to enter the market or not. A pilot plant on a semi-commercial scale can be expensive, but the classic research comment is that mistakes are best made on a small scale if profits are to be made on a large one.

As with all industrial research, the large costs of new food product development come at the advanced stages. It is, therefore, a matter of ultimate great economy or profit to be generous of time, money, and managerial attention in the earliest stages. Duplication in research at this stage is not the inefficient administrative bugbear some shortsighted management would make it. Several prospecting parties can be a source of profit if they increase significantly the probability of finding a gold mine, or even of finding the better of two before the expense of sinking deep shafts begins.

Not all new food projects can be sold for the reputed 10 to 20 millions General Foods once paid for the Birdseye process and name.[1] But that sale, even as an historic maximum, is an indication of the order of magnitude of costs and values involved in new food product development. With all the resources available to Swift, including the momentum of its sales organization, we have in the 2 to 3 year period for the introduction of meat as a baby food perhaps a record minimum for a significant new product in successful national distribution. The new quick-cooking cereal product took 5 years from the time the project was authorized until it was seriously on the market. The new vacuum-dried soluble coffee was approximately 7 to 8 years in the development and proving stage. "Accent," the monosodium glutamate accentuator of food flavors took at least 6 years before serious national advertising and distribution was attempted. During these periods appreciable sums were spent on all these products, for product improvement and standardization, for process development, pilot operations and surveys, and for investigations of nutritional, functional, commercial and other aspects, even before market trials were attempted.

Nor can success be guaranteed. Lever Brothers went through all stages of research, development, evaluation, trials and then actual national marketing of a new vitamin product, only to withdraw it from the market, presumably as an unprofitable item. A leading proprietary and pharmaceutical manufacturer carried a new food supplement to the stage of product specification, with the knowledge that nutritionally the special product had merit, only to find it unsuited in its final form to its sales and distribution policy. Powdered orange juice seemed promising, indeed it led to frozen orange juice, but the original project was abandoned. Unlike provision for manufacture of more of a known and commercially accepted product, the development of a new food product must be recognized as completely speculative until the black ink is thoroughly dry on last year's profit and loss sheet.

Many of the steps in the development of new food products are common to the records of all the principal recent additions to the food distribution outlets. These follow the all-important discovery or identification of the new product and the early phases of commercial evaluation, by which means serious consideration and development is justified to management.

COMMERCIAL EVALUATION OF NEW PRODUCTS

Great strides have been made within the last decade or two in providing management with quantitative bases for decisions that were formerly made on "judgment" based on individual experience or intuition. Organized market appraisals have become increasingly common and their methodology is under constant refinement. The sales department is no longer depended upon for objective reports or studies as a side issue of its real purpose in life, unless a separate well-organized market research unit is maintained within it independent of normal sales activity. Neither in the discovery of new products or markets nor in the critical evaluation of such products is the normal sales staff successful, qualified or for that matter sincerely interested. The early phases of product discovery, and market as well as technical evaluation are frequently better suited to the interests, qualifications and activities of the executive in charge of research and his associates. Their business is the future, concerned with change and with new things and new activities. By contrast sales and production are more apt to be concerned with doing better and doing more of what is now being done. The point at which transition to sales and production is to be made depends upon personalities, organization and experience of the particular company, and this and other aspects of the transition involve some of the more difficult managerial problems incident to efficient operation of research and development. Normally the commercial market for a product is determined in stages, with more extensive and elaborate surveys made as development progresses and the amount of money required increases. Initial technical and commercial evaluation are elementary, and draw heavily on the background and judgment of the research directorate. The important point is that both technical and commercial evaluation and development continue, hand in hand, from the start. Some years ago a research staff developed a substitute for ammonia, basing its enthusiasm on the fact that the new product did not have the irritating biting odor of ammonia. Eventually, it was sent for consideration to an able distributor of household products, who had market checks made. He reported that he could perhaps sell the new product, at a price—if the researchers would add an odor like ammonia so the housewife would know it had authority. The technical laboratory is not the place to evaluate commercial possibilities.

Raw materials available may be a controlling factor in the ultimate scale of operations, and their availability, cost and quality need early and serious consideration.

Fortunately, Birdseye and his associates and early successors realized the need of high quality and their early researches included consideration of types and varieties, harvesting and special handling incident to quick freezing of high grade food products. Had they spent less time, money and effort on this aspect, the rate of expansion of the new industry presumably would have been changed, perhaps disastrously.

Raw materials that are themselves by-products or associated products can be hazardous. Both quantity and price may be dependent on factors not within control for the particular project. In particular, as with all by-product research, care should be taken that the project is not aimed primarily at disposing of the by-product rather than making money out of the new project. Too often new products have been developed expensively from by-products, only to find that they cannot compete with better or cheaper products made from another raw material available to competition on the open market. Both with by-products and with normal products, the effect of increased demand on cost and availability need consideration.

Most proposed new products have apparent negative factors—sales handicaps. A new fish product for baby foods, for example, developed a harmless crystalline substance that looked to the purchaser like sharp foreign matter. Until laboratory research found acceptable methods for prevention of this crystal formation the product was withheld even from serious preliminary market trials. It pays to be critical in the early stages, and proper evaluation can only be made with a product approximating that the customer will eventually buy. In the early development of one of the principal hydrogenated oils, the Salvation Army received many a barrel of doughnuts cooked in a study of rancidity control. Practically all new food products now go through an intensive laboratory research and development period that continues even after introduction to the consumer markets.

It is only recently that the major acceptance factor of many food products—flavor—has come within a reasonable degree of quantitative control. The new methods of flavor evaluation, including the use of the flavor profile or related approaches, permit measurement of the effect of formulation and process changes. They provide communication between the taste specialists and the purchasing and operating men that can affect flavor changes. They bring flavor out of the realm of the prima donna type of taster, brewmaster or "indispensable old hand" into control of management.

There have been two types of flavor panels, one concerned with technical aspects, almost neglecting preference, and the other the consumer panel concerned almost exclusively with preference. There are indications recently that many aspects of consumer preference can be anticipated in the laboratory, with a trained small panel, at appreciable saving and with increased reliability as a basis for management decisions.

Shelf life is frequently a major problem. Completely satisfactory laboratory methods of predicting product changes with aging have never been developed even for products for which major studies of aging tests have been made, such as paint and rubber. For new food products there is no safe and certain short cut. Aging tests must be started early and careful observations and records made. Merely setting packaged samples on the shelf for examination at intervals is not adequate. On new nationally distributed products, experimental shipments have been made to include such areas as the southwest, where freight car temperatures may reach 130° F. (54.4° C.). A product may keep well in New York and have its life shortened by humidity in New Orleans. Fortunately the container industry has accumulated a wide knowledge of methods of avoiding troubles that once were common because of inadequate or improper packaging. The container sales service man can be helpful. Accelerated tests, as for effect of antioxidants, by effect of exposure to heat and humidity, etc. can and should be made in the laboratory, but they are laboratory tools, not complete equivalents of practical distribution conditions and experience.

The package itself is a special problem, and its choice all important. Market tests and records suggest that package appearance is a major factor in consumer acceptance, as would be assumed. The industrial designer who designs the package may make as great a contribution as the chemist who adds an antioxidant to extend the shelf life of the flavor. Cost, flavor protection, moisture or vapor tightness or, conversely, some porosity to allow "breathing" as well as ability to stand normal shipment and store handling are all factors to be considered.

Before any new food product can go on the market, involving interstate shipment, it should comply with the Federal Food, Drug and Cosmetic Act of 1938. This legislation, in essence, prohibits the adulteration or misbranding of foods. And, under the Act, any food containing a poisonous or deleterious substance which may render the food injurious to health is automatically deemed adulterated. The law also empowers the Government to set standards of identity for foods, prescribing required or optional ingredients that can be employed by the manufacturer. Since the law was enacted, approximately 300 individual food products have been "standardized." New food products which fall within products bearing standards of identity must comply with the existing regulations. Standards of identity may be modified upon petition to the Administrator to reopen hearings for the presentation of evidence concerning the proposed additions or changes. Any new product should also comply with the packaging and labeling requirements as outlined in the Federal Food, Drug, and Cosmetic Act.

Under the present law, it is the manufacturer's responsibility to assure that a food meets the required standards. At present it is the manufacturer's concern that no new chemical will be added to a new food product prior to adequate toxicological testing to demonstrate its safety for the proposed use. The establishment of the non-toxicity of a chemical ingredient can, and usually does, involve several years of clinical experimentation.

Marketing and distribution policies depend in large part on the existing structure, practice and distributor relationship of the sponsoring company. A few city-wide distribution trials coupled with local advertising

give further checks on consumer acceptance and permit refinement of advertising and distribution policies. Regional or national advertising programs are geared to introduction and initial distribution and the product is launched. Hopefully. The record shows that optimistic reports even through the initial stages of national distribution are no guarantee.

If the new product succeeds, it has a life expectancy of a human generation. We have only to look at the record of several of the breakfast cereals, from the early corn flakes and shredded wheat on to see the large order of magnitude of income that may result if success is achieved. The food industry as a whole is our largest industry, and the market is enormous and continuous. Anyone who has tried to find industrial outlets for agricultural products significant by comparison with food consumption realizes the great discrepancy in size of the two markets. No industrial use for sugar, for example, ever gave significant aid to the industry in periods of serious over-production.

THE FUTURE FOR NEW PRODUCTS

Success stories are plentiful and exciting enough to support further prospecting in the field. The failures have not had the same publicity as the successes—the best advertising brains have not spent millions telling the world about products that have been put on the shelf rather than on the shelves. The stake is enormous and any company that has a new approach to the consumer food market is justified in exploring it, making reasonably sure that it has the means and the organization to back the project through what may be 5 to 15 years of speculation. The less radical changes involve less hazard, less time and offer a correspondingly smaller stake. The speculative nature of the enterprise makes it advisable to take every possible step toward insuring success and keeping management informed of technical and commercial aspects continuously as the project advances and the amounts hazarded increase. The several steps in the development of new food products are known and definable. In each, specialized experience is available to management, and it is no longer necessary to play a blind hand.

Backarach defined nutrition as the science of what other people ought to eat. But nutritionists have carried on an educational program paralleling research, and the public is increasingly appreciative of improvements in nutritional values as well as attractive appearance, tempting flavor, and uniformly dependable high quality as purchased by the consumer under a recognized name. There is still much left to be desired in the quality of many food products as now served on our tables. There is no reason to believe that we have begun to exhaust the possibilities of improved food products. Our increasing populations and increasing complexity of food distribution and changing pattern of living continue to create both problems and attractive commercial opportunities within the industry that leads all others in size and significance. The public will continue to derive great benefit from the efforts of successful entrepreneurs in the new food products field. The potential gain to producer and consumer is great.

Deterioration in Frozen Pork as Related to Fat Composition and Storage Treatments[a,b]

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The keeping quality of frozen ground pork declined with a decrease in the saturation of pork fat. This deterioration was most marked at temperatures above 0° F. (—18° C.) and when packaged in inferior oxygen-moisture vapor barrier materials. These tendencies were less pronounced in the case of chops and roasts. The effect of fluctuating temperatures was not progressive in nature and was of less practical significance than prolonged storage at temperatures above 0° F. (—18° C.).

During freezer storage, pork deteriorates more rapidly than beef or lamb. This is due, apparently, to the greater unsaturation of pork fat which increases its susceptibility to rancidity development, and also, to the high fat content of most pork cuts.

With an increase in the proportion of unsaturated fatty acids, pork fat becomes softer. Feeds such as soybeans and peanuts produce soft pork, when comprising a substantial part of a ration, because they are high in fat *(6, 11, 15, 18, 19)* that is relatively unsaturated *(3, 11)*. When these feeds comprise a limited part of the ration, as is usually the case, the change in apparent quality of the pork is small.

The work of Brady *et al. (5)* with cured pork clearly indicates that the soft fat is more susceptible to oxidative deterioration (rancidity development) during storage than hard fat. Lea *(27)* and Barnicoat *(2)* have also shown that fat saturation influences the rate at which pork becomes rancid during storage. Helser *et al. (15, 16)* found that rancidity increased as the saturation of lard decreased. Klose *et al. (24)* and Kummerow *et al. (25)* have shown that the storage life of turkey meat is significantly influenced by the saturation of the carcass fat. Shrewsbury *et al. (32)*, however, stored pork chops and roasts from hard and soft carcasses at —6.3° F.

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(—21.3° C.), —8.4° F. (—22.4° C.), and —8.2° F. (—22.3° C.) for periods up to 16 months and found that the fat from the soft carcasses showed no greater tendency to become rancid than the fat from the firm carcasses. There is, however, a question as to whether or not a decrease in the firmness of the pork fat is associated with a proportional reduction in the storage life of fresh frozen pork.

It is generally recognized that as fats become oxidized they also become rancid in aroma and flavor *(8, 26, 40)*. The length of the induction period and the rate of rancidity development are influenced by a, the storage temperature *(7, 22, 32)*, b, the efficiency of the packaging material as an oxygen-moisture vapor barrier *(9)*, and c, other factors such as organic and inorganic catalysts *(21, 26, 39)*, radiation *(36)*, and natural occurring antioxidants *(25)*.

Fluctuations in temperature have been reported by Black *(4)*, Finnegan *(12)*, Woodroof *(41)*, and Woodroof and Shelor *(42)* to have a deleterious effect on the storage of frozen foods. These findings are not, however, in agreement with the results reported by Gortner *et al. (13)*, Hustrulid and Winter *(20)*, and Klose *et al. (22)*. Before broad generalizations can be drawn it is necessary that further studies be made. The effects of various storage temperatures and packaging materials on the development of oxidative rancidity in firm pork are well established *(10, 14, 30, 31, 38, 43)*. Similar information is not available for soft pork which presumably is more susceptible to oxidative rancidity. If soft pork deteriorates more rapidly in freezer storage than firm pork, then from a practical standpoint the use of optimum storage temperatures and efficient packaging materials are highly desirable.

The primary objective of this investigation was to determine the influence of fat saturation on the deterioration of frozen pork. Secondary objectives were to determine the influence of various storage temperatures, fluctuating temperatures, and packaging materials on the keeping quality of pork. The relationship between subjective and objective measures of rancidity was of interest also and has been reported by Naumann *et al. (29)*. In the light of apparent discrepancies in the literature concerning the effect of several variables on the keeping quality of pork, this investigation was designed in such a way that several variables could be considered with the same sampling material.

EXPERIMENTAL PROCEDURE

The pork used in this investigation was obtained from 20 hogs that were divided into 4 lots of 5 hogs each for the feeding of the experimental rations. Two rations were fed in the finishing of the hogs: a "hard" ration so designated because it was known to be conducive to firm fat deposition and a "soft" ration so designated because it contained soybeans which are known to be conducive to soft fat deposition. The hogs in Lot 1 served as the control group and made no gain on the "soft" ration, whereas hogs of Lots 2, 3, and 4 gained an average of 36, 73, and 107 pounds, respectively, on the "soft" ration.

After slaughter, the carcasses were chilled 48 hours at 36° F. (2.2° C.) and graded according to the following classification: Hard, Medium Hard, Medium Soft, Soft, Oily. As the number of pounds gained on the "soft" ration increased from lot to lot, the carcasses became softer, and the iodine absorption number, determined by the Hanus Method *(1)*, of the ground pork fat increased. Lots 1, 2, 3, and 4 graded "hard," "medium hard," "medium hard," and "medium soft" and had average iodine numbers of 58.75, 63.68, 65.18 and 68.44 respectively.

The bellies, jowls and shoulders from each hog were ground twice, uniformly shaped into 30 one-pound samples and packaged as follows: 15 in a glassine laminated to kraft freezer paper and the other 15 in a waxed freezer paper. Twelve one-inch center cut chops and two loin-end roasts were taken from each hog. The chops (three to a package) and the roasts were wrapped in the laminated paper.

All samples were frozen on —10° F. (—23° C.) coils. Ground pork was stored for periods of 3, 6, and 9 months at 0° F. (—18° C.); 10° F. (—12° C.); 0° and 10° F. (—18° C. and —12° C.) alternating each week; 0° F. (—18° C.) storage with one defrosting thawed to an internal temperature of 40° F. (4.4° C.); and 0° F. (—18° C.) storage with 3 defrostings. Pork chops were stored for periods of 3, 6, 9, and 12 months at 0° F. (—18° C.). Roasts were stored for 6 and 12 months at 0° F. (—18° C.).

The flavor and the odor of the cooked samples were scored as to desirability and rancidity. Peroxide and free fatty acid values were determined on the uncooked samples. The samples were thawed at 38° to 40° F. (3.3° to 4.4° C.) and placed at room temperature shortly before testing. This was done to facilitate thorough mixing of the ground pork and to insure complete defrosting of the roasts and chops.

Much consideration was given to the problem of proper sampling technique. Since oxidation proceeds from the exterior to the interior there may be a marked variation in the depth of penetration and in the character of the gradient depending upon the influence of the variables. Thus, the meat may be sampled from the surface or aliquots may be taken of the whole sample for the various determinations. It is the considered opinion of the authors that the latter method is preferable. While the use of the whole sample results in lower organoleptic and peroxide values, these nevertheless can be compared. Surface sampling has marked limitations. The samples must be of uniform dimensions, and the sampling must be standardized to a depth which will include more than the surface in order to provide adequate material for the various determinations. Seasoned and unseasoned fresh pork sausage is also customarily kneaded and molded into patties prior to cooking, which results in the mixing of the surface with the whole sample. Thus, any surface relationship is largely lost, and would show little correlation to the deterioration of the whole sample.

A 100-g. aliquot from each ground pork sample was made into a patty one-half inch in thickness. The patty was placed in a small earthenware casserole, covered with a lid and cooked in a preheated oven for 50 minutes at 300° F. (150° C.). One outside pork chop from each package was cooked the same way while the other outside pork chop was used for chemical analysis. A one and one-half inch thick cross section from the center of the pork roasts was cooked similarly but for 90 minutes. Only the outside one-quarter inch of fat on the chops and roasts was used for chemical and organoleptic tests.

Peroxide values were determined by the procedure of Stansby *(36)* with the extraction of the external fat of the chops and roasts modified according to Watts *(38)*. The free fatty acid content was determined according to the A.O.A.C. procedure *(1)* and calculated on the oleic acid basis. Chemical and organoleptic tests were made on aliquots of the same sample and on the same day.

Main effect differences, i.e., those between lots, between packaging materials, between storage treatments, and between storage periods, were tested for significance by the analysis of variance calculated according to Snedecor *(34)* and correlation coefficients were determined as described by Mills *(28)*. The significance of difference between the means was ascertained as described by Snedecor's T-test *(35)*. Correlation coefficients involved 480 samples of ground pork that had been stored at 0° F. (—18° C.), 10° F. (—12° C.), and 0° and 10° F. (—18° C. and —12° C.) alternating weekly for 3, 6, and 9 months. The group of samples used in the calculation of correlation coefficients differed from the group of samples used in the calculation of the analysis of variance in that samples defrosted one and three times were omitted.

TABLE 1

Significance of differences between treatments

Treatments	Lot 1	Lot 2	Lot 3	Laminated paper	0° F.	10° F.	0-10° F. weekly	1 Defrosting	3 Months' storage	6 Months' storage
Lot 2	* —									
Lot 3	** oo	oo								
Lot 4	** oo	** o	* —							
Waxed paper				** oo						
10° F.					** oo					
0-10° F. weekly					— —	** oo				
1 defrosting					** —	** oo	** o			
3 defrostings					** oo	— oo	** oo	* oo		
6 months' storage									** oo	
9 months' storage									** oo	** oo

— No significant difference at the 5% level.
* Significant difference in flavor rancidity at the 5% level.
** Significant difference in flavor rancidity at the 1% level.
o Significant difference in peroxide values at the 5% level.
oo Significant difference in peroxide values at the 1% level.

RESULTS

The significances of differences in flavor rancidity and peroxide values for the different treatments are shown in Table 1. This means has been used to condense in tabular form the essential comparisons made between the various treatments and will be discussed under individual headings.

Fat saturation. In ground pork, fat saturation had a pronounced influence on the susceptibility to rancidity development when measured by flavor and peroxide values. The higher peroxide values of Lot 3 when compared with Lot 4, however, were not significantly different.

While the differences due to fat saturation (Table 2) do not seem to be great it should be pointed out that each value represents samples from all of the temperature treatments, packaging materials, and storage periods. Many of these variables have a pronounced effect individually, as will be shown later, but when combined they do not exhibit the striking difference from lot to lot that might be expected. In general, as the firmness of the fat decreased, as indicated by increased iodine number, the fat became more susceptible to rancidity.

Packaging materials. Superior packaging offered greater protection against rancidity development (Table 2). A striking difference was also noted in the efficiency in preventing dehydration. Meat packaged in the waxed paper had more than 5 times greater dehydration loss than that packaged in the laminated paper. The result, with the waxed paper, was a severe freezer burn, particularly with those samples stored at 10° F. (—12° C.) and those which were defrosted. No appreciable difference in dehydration was observed between the 0° F. (—18° C.) and the 0° and 10° F. (—18° C. and —12° C.) alternating weekly samples.

TABLE 2

Effect of treatments on flavor rancidity scores and peroxide values of ground pork [a]

Treatment	Flavor rancidity score [b]	Milliequivalents of peroxide per kilogram of fat
Fat Saturation		
Lot 1 (Iodine No. 58.75)	3.68 ± .05	1.83 ± .15
Lot 2 (Iodine No. 63.68)	3.48 ± .06	2.31 ± .23
Lot 3 (Iodine No. 65.18)	3.37 ± .06	3.83 ± .36
Lot 4 (Iodine No. 68.44)	3.21 ± .07	3.34 ± .36
Packaging Material		
Laminated Paper	3.60 ± .03	2.44 ± .20
Waxed Paper	3.27 ± .05	3.22 ± .22
Storage Temperature		
0° F.	3.70 ± .05	2.17 ± .28
10° F.	3.22 ± .08	4.21 ± .49
0-10° F. Weekly	3.60 ± .06	1.89 ± .22
1 Defrosting	3.39 ± .06	2.39 ± .24
3 Defrostings	3.27 ± .06	3.48 ± .32
Length of Storage		
3 Months' Storage	4.05 ± .03	1.20 ± .14
6 Months' Storage	3.38 ± .04	2.15 ± .11
9 Months' Storage	2.88 ± .05	5.22 ± .35

[a] In this factorially designed experiment, a total of 600 samples were allotted to experimental treatments as follows:
150 samples per lot.
300 samples per packaging material.
120 samples per storage temperature.
200 samples per storage period.
[b] Flavor rancidity scores: 1—Very rancid; 2—rancid; 3—slightly rancid; 4—neutral or flat; 5—normal or sweet.

Temperature treatments. Since storage above 0° F. (—18° C.) for prolonged periods is not generally satisfactory, it is interesting to compare the effect of 0° and 10° F. (—18° and —12° C.) alternating weekly with 0° F. (—18° C.) storage (Table 2). Clearly there is no appreciable difference between these. In contrast, the effect of prolonged storage at 10° F. (—12° C.) was the most severe. Some explanation for the comparative

efficiency of 0° and 10° F. (—18° and —12° C.) alternating weekly storage may be offered by considering the actual conditions of the fluctuations. While the samples involved in the fluctuating treatment were in a 10° F. (—12° C.) atmosphere only half as long as the 10° F. (—12° C.) group, the samples themselves were probably at temperature equilibrium with that atmosphere for a much shorter time. Hence, deterioration was retarded much more effectively than at 10° F. (—12° C.). These results are in agreement with those of Gortner *et al. (13)* and Hustrulid and Winter *(20)*.

Significantly, 3 defrostings followed by 0° F. (—18° C.) storage was equally severe in effecting flavor as 10° F. (—12° C.). Here, too, some explanation should be made concerning physical accomplishment of the defrosting treatment. The defrostings occurred during the first month of storage with complete freezing between defrostings. Whether similar changes would have resulted had the defrostings occurred later in the storage life is problematical. Actually, the defrostings had an immediate and pronounced effect which accounted for most of the total deterioration. This resulted in the defrosted samples being definitely inferior at the 3-month period but little worse after 6 or 9 months' storage, whereas the samples stored at 10° F. (—12° C.) showed a constantly increasing rate of deterioration. Deterioration during storage was progressive and pronounced with time under all storage conditions.

Interactions. Since 2 variables may have independently and simultaneously influenced the acceptability of the ground pork, it was desirable to calculate first order interactions in order to determine whether or not the two factors complemented each other. Interactions were determined with only the data of the ground pork stored at 0° F. (—18° C.), 10° F. (—12° C.) and with 3 defrostings (Figure 1).

There were significant differences between packaging materials within each lot on the flavor rancidity of frozen ground pork. Similar differences were noted in the peroxide values. While flavor rancidity scores declined with an increase in iodine number regardless of packaging material, the decline was greatest in the ground pork packaged in waxed paper. With an increase in iodine number, regardless of packaging material, peroxides increased. The increase was again greatest in the pork packaged in waxed paper. The first order interaction between fat saturation and packaging material was not significant in either criterion used in evaluating the pork—flavor rancidity or peroxide value. This means essentially that the sum of the effects of the 2 factors, fat saturation and packaging material, was sufficient to account for practically all of the variability in the flavor rancidity scores and peroxide values.

There was an influence of fat saturation and storage temperature on the development of rancidity, as detected by flavor and peroxide value. It is apparent that regardless of storage temperature, the fat saturation had a pronounced effect upon the keeping qualities of frozen ground pork.

In both criteria used in measuring deterioration, a significant first order interaction existed between fat saturation and length of storage. It may be stated, therefore, that deterioration was significantly more rapid in the ground pork with the higher iodine values (Figure 2).

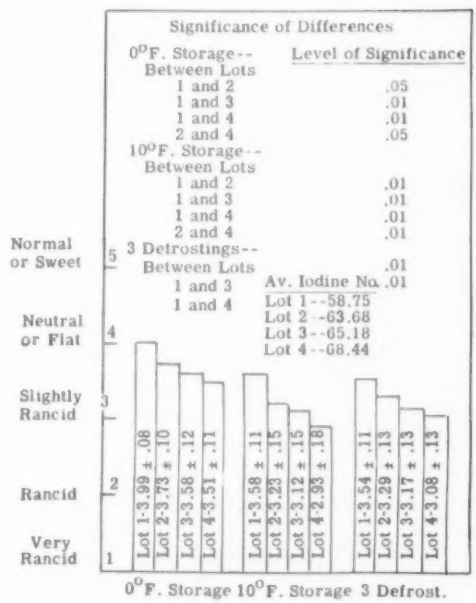

Figure 1. Influence of fat saturation and temperature treatment on flavor rancidity of frozen ground pork.

Correlations. Coefficients of correlation presented in Table 3 were calculated to determine the relationship between flavor desirability and other factors. The correlations with peroxide numbers were not significant at 3 and 6 months' storage, but highly significant after 9 months' storage. The correlations with per cent free fatty acid, though in some instances highly significant, were low. Correlations with per cent dehydration were

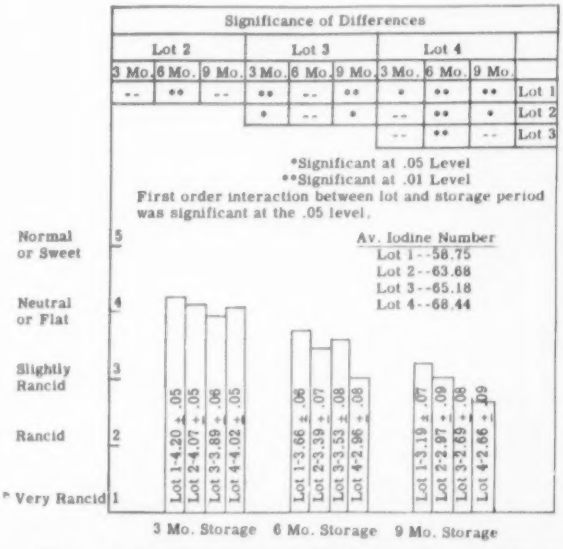
Significance of Differences
Lot 2
Lot 3
Lot 4
3 Mo. 6 Mo. 9 Mo. 3 Mo. 6 Mo. 9 Mo. 3 Mo. 6 Mo. 9 Mo.
-- ** -- ** -- ** * ** ** Lot 1
* -- * -- ** * Lot 2
-- ** -- Lot 3
*Significant at .05 Level
**Significant at .01 Level
First order interaction between lot and storage period was significant at the .05 level.
Av. Iodine Number
Lot 1--58.75
Lot 2--63.68
Lot 3--65.18
Lot 4--68.44
Normal or Sweet
Neutral or Flat
Slightly Rancid
Rancid
Very Rancid
5
4
3
2
1
Lot 1-4.20 ± .05
Lot 2-4.07 ± .05
Lot 3-3.89 ± .06
Lot 4-4.02 ± .05
Lot 1-3.66 ± .06
Lot 2-3.39 ± .07
Lot 3-3.53 ± .08
Lot 4-2.96 ± .08
Lot 1-3.19 ± .07
Lot 2-2.97 ± .09
Lot 3-2.69 ± .08
Lot 4-2.66 ± .09
3 Mo. Storage 6 Mo. Storage 9 Mo. Storage

Figure 2. Influence of fat saturation and length of storage period on flavor rancidity of frozen ground pork.

TABLE 3

Coefficients of correlation

	r Value (Lot and storage temperature groups combined) Flavor desirability and:			
	Peroxide number	Percent free fatty acid	Percent[1] dehydration	Odor desirability
Three Months				
Laminated Paper	−.03	−.05	+.03	+.40**
Waxed Paper	+.16	+.06	−.14	+.40**
Pkg. Materials Combined	+.09	+.01	−.11	+.40**
Six Months				
Laminated Paper	−.14	−.71**	−.24	+.56**
Waxed Paper	−.14	−.20	+.02	+.61**
Pkg. Materials Combined	−.05	−.43**	−.19*	+.59**
Nine Months				
Laminated Paper	−.32*	−.11	−.12	+.84**
Waxed Paper	−.16**	−.55**	−.75**	+.64**
Pkg. Materials Combined	−.15**	−.35**	−.49**	+.74**

[1] Dehydration expressed as percent loss in weight.
* Significant at .05 level.
** Significant at .01 level.

also highly significant in some cases. Highly significant correlations were obtained with odor desirability. In general, however, the relationships between flavor desirability and other factors were too small to justify their substitution for flavor desirability.

Pork chops and roasts. The chemical and organoleptic data indicated that fat saturation had no significant effect on the keeping quality of frozen pork chops and roasts. There was, however, a significant decline in palatability during storage.

Results of this investigation support the work of Brady *et al. (5)*, Lea *(27)*, and Barnicoat *(2)* who also demonstrated that decreased storage life of pork resulted from a decrease in the saturation of the pork fat. This investigation would also support the finding of Shrewsbury *et al. (33)* that fat saturation does not appreciably influence the deterioration of pork chops and pork roasts stored at acceptable temperatures. Defrosting allowed excessive deterioration of pork fat in this investigation and agrees with the work of Black *(4)* and Gortner *et al. (13)* but is somewhat at variance with the work of Klose, Hanson and Lineweaver *(23)*.

SUMMARY AND CONCLUSIONS

Fat saturation, firmness of fat, had a significant effect upon the keeping quality of ground pork. Pork from hogs fed limited quantities of soybeans was more susceptible to rancidity development than pork from hogs fed a ration producing firm fat. It is important, therefore, that pork from hogs fed rations conducive to soft fat deposition be packaged properly and stored at 0° F. (−18° C.) or lower.

Defrostings have a deleterious effect on the palatability of frozen ground pork although these effects may be less objectionable than prolonged storage at 10° F. (−12° C.).

Palatability scores were highest for those samples of ground pork from firm carcasses which had been packaged in superior packaging materials and stored at 0° F. (−18° C.).

Firmness of fat had no significant effect on the keeping quality of pork chops and roasts packaged in a superior packaging material and stored at 0° F. (−18° C.).

Correlation coefficients between objective and subjective methods of evaluating the quality of ground pork were of such limited size as to be of little practical value.

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An Evaluation of Some of the Factors Affecting the Stability of the Crystal Texture of Recrystallized Honey

G. H. AUSTIN and C. A. JAMIESON
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(Manuscript received June 17, 1952)

The relationship between moisture content, levulose to dextrose (L/D) ratio and the "breakdown" of the crystal texture of recrystallized honey during storage was measured by a modified "Penetrometer." Recrystallized honey having an L/D ratio above 1.14: 1 should contain less than 18% moisture in order to insure stability of crystal texture. For such honey a "shelf-life" of at least four months may be predicted. In honey having a lower L/D ratio the moisture content need not be so stringently controlled.

The introduction of the Dyce process *(4)* for recrystallizing pasteurized honey was a significant contribution to the beekeeping industry. So successful has the method been in Canada that a large percentage of the honey crop is now marketed in this form. However, various factors inherent in certain recrystallized honeys effect a "breakdown" in the crystal texture under the normal storage conditions that prevail in the trade.

It is well known *(1, 2, 4)* that the firmness of texture of any recrystallized honey is a direct consequence of its moisture content and of its levulose to dextrose (L/D) ratio. Both factors are interrelated in that the coefficient of supersaturation (and hence rapidity of crystallization) of any honey *(5)* may be interpolated from their intrinsic values. However, for simplicity, they are dealt with as separate variables in this investigation.

No method of placing finite values on the solidity of recrystallized honey has hitherto been proposed. Consequently, the effect of changes in L/D ratio and moisture content on the stability of recrystallized honey could not be definitely established. The modification of a standard instrument used in the petroleum industry to measure the solidity of heavy grease has made possible an evaluation of the effect of these factors. The instrument used, a "Penetrometer," measures the depth in tenths of millimetres that a weighted needle penetrates a substance in a given time. The standard instrument was adapted to our purpose by increasing the length and the diameter of the needle.

While the moisture content and levulose to dextrose ratio of honey are the main factors affecting its crystallizing properties, such minor components as colloidal protein and titratable acidity may also be involved. Since the latter vary considerably in honey from different floral sources, it was necessary, in order to minimize such effects, to use one particular honey throughout the investigation.

PROCEDURE

An Ontario white honey was selected because of its unusually high (1.28:1) L/D ratio. Such a sugar relationship in the basic material simplified the adjustment of the L/D ratio of separate lots to intermediate and low values since in each case only the required amount of dextrose needed to be added.

Analyses of each lot after the L/D ratio was adjusted revealed that the observed value coincided with the calculated value within the limits indicated.

The moisture content of samples from each lot was adjusted in one per cent increments from 16% to 20%. The refractometer method *(3)* of moisture determination was used throughout. A summary of the scope of treatment is shown in Table I.

TABLE I
Moisture content and L/D ratios of samples tested

Samples	Moisture*	L/D Ratio
	%	
A16–A20	16.0±0.2–20.0±0.2	1.28:1
B16–B20	16.0±0.2–20.0±0.2	1.14:1
C16–C20	16.0±0.2–20.0±0.2	1.0 :1

* Moisture content determination by refractometer.

After pasteurization, the honey in each treatment was held at 75° F. (24° C.) for 15 minutes while 7% by weight of finely granulated "seed" honey was incorporated by stirring. Twelve samples from each lot were drawn off into 4-ounce, screw-capped jars, the tops of which were sealed with cellotape. All samples were stored at 57° F. (14° C.) for one week to allow crystallization to become complete. All but 2 samples from each treatment were removed from the refrigerator and stored at room temperature to simulate conditions which prevail in the trade. Penetrometer readings were taken on duplicate samples from each treatment immediately. The same procedure was repeated one week later, when all samples had attained equilibrium

with the room temperature. Readings were taken at monthly intervals thereafter, on 2 samples from each treatment. In all cases the depth of penetration during a 10-second period was measured.

RESULTS AND DISCUSSION

The values in Table 2 are the means of 5 measurements taken on each of 2 samples at the times indicated.

In series A (L/D ratio — 1.28:1.00), samples having a moisture content of 17% or less remained reasonably firm throughout the experimental period although progressive softening in group A 17 is apparent. This latter tendency is more striking in samples having a higher moisture content.

TABLE 2

The effect of storage on the texture of recrystallized honey

Sample No.	Penetrometer Reading[b] in mm.							
	Sept. 15	Sept. 22	Oct. 22	Nov. 22	Dec. 22	Jan. 22	Jan.[c] 22	Jan.[d] 29
A16	11.2	11.2	9.7	8.0	8.1	8.6	3.9	6.5
A17	10.4	11.0	11.2	10.8	24.1	30.2	5.7	10.5
A18	11.5	13.8	13.8	17.7	34.8	45.0*	5.5	13.0
A19	12.0	20.9	20.9	45.0	45.0*	45.0*	7.2	17.1
A20	12.2	22.5	22.5	45.0*	45.0*	45.0*	7.7	26.0
B16	6.5	7.2	5.4	5.1	5.9	6.6	2.8	5.8
B17	5.5	6.0	4.9	4.7	6.3	7.0	2.6	4.7
B18	5.8	7.8	6.9	8.6	11.0	11.0	3.2	6.6
B19	6.2	8.6	9.4	13.0	14.9	22.5	3.4	7.8
B20	7.5	10.5	15.5	18.0	35.8	43.8	3.5	8.1
C16	2.6	5.7	5.1	5.8	5.9	6.0	2.1	4.4
C17	2.8	5.3	4.8	5.2	5.9	5.7	2.2	4.7
C18	3.2	5.2	5.2	5.5	7.7	7.6	3.0	4.9
C19	3.4	5.9	7.7	7.9	9.4	9.7	3.2	5.3
C20	3.8	7.9	12.0	13.9	22.0	34.7	3.3	7.4

[b] Means of 5 readings taken on duplicate samples.
[c] Readings from samples held for four months at 57° F.
[d] Readings from c samples after one week storage at room temperature
* Partial change of state.

It will be noted that 45 mm. is the maximum depth of penetration that can be measured with the Penetrometer. However, only those samples which had undergone a partial change of state, i.e., separation of liquid and solid phase, gave readings in this range.

A progressive breakdown with time is noted in series B and C (L/D ratios — 1.14:1 and 1.00:1 respectively) although only in group B 20 does this reach dangerous proportions after four months storage at room temperature. It may, in fact, be predicted from these results that in any honey having an L/D ratio of 1.14:1.00 or less and a moisture content of not more than 19%, a "shelf-life" of at least 4 months may be expected. Indeed, an examination of experimental samples in this group showed no appreciable change in texture after 6 months of storage at room temperature.

In samples held at 57° F. (14° C.) (c, d, Table II) throughout the experimental period no apparent change occurred regardless of L/D ratio or moisture content. Obviously then, recrystallized honey should be held at 57° F. (14° C.) if it is not to be retailed immediately.

In all groups during the early part of the trial, the samples containing 17% moisture appeared to be somewhat firmer than those with a moisture content of 16%. Such differences were not clear cut, but they indicate that the optimum moisture content for honey in so far as firmness of set is concerned lies between 16% and 17%.

A rather interesting side-effect of decreasing the L/D ratio of this particular honey was the increasingly lighter colour of the products. The lighter colour is probably due to a more rapid, and therefore, finer crystallization taking place in the honeys with a higher dextrose content.

Certain recommendations may be tentatively suggested from the above results. Honey that is to be marketed in the recrystallized state should not have a moisture content higher than 18%. Secondly, only those honeys which have a natural L/D ratio of about 1.14:1 or less should be packed as recrystallized honey. In this class may be included alfalfa, sweet clover, basswood and buckwheat honey. As a consequence, the processor has a fairly wide selection from which to choose honey for his recrystallized pack. Furthermore, since the tendency towards crystallization decreases as the L/D ratio and moisture content increases *(5)*, any honey that is excluded from the recrystallized pack by the above recommendations is admirably suited for packing as liquid honey.

SUMMARY

The effect of varying moisture content and L/D ratio on the stability of crystal texture of recrystallized honey stored at room temperature was measured by a new instrument (Penetrometer).

Recrystallized honey which is not to be marketed immediately should be held in storage at 60° F. (15.5° C.) or lower.

The moisture content of honey having an L/D ratio greater than 1.14:1 should be less than 18%, in order to insure a stable crystal texture in the product. The moisture content need not be so stringently controlled provided the ratio is lower than the above.

When the above 2 factors are controlled within the prescribed limits a "shelf-life" of not less than 4 months may be predicted for the processed honey.

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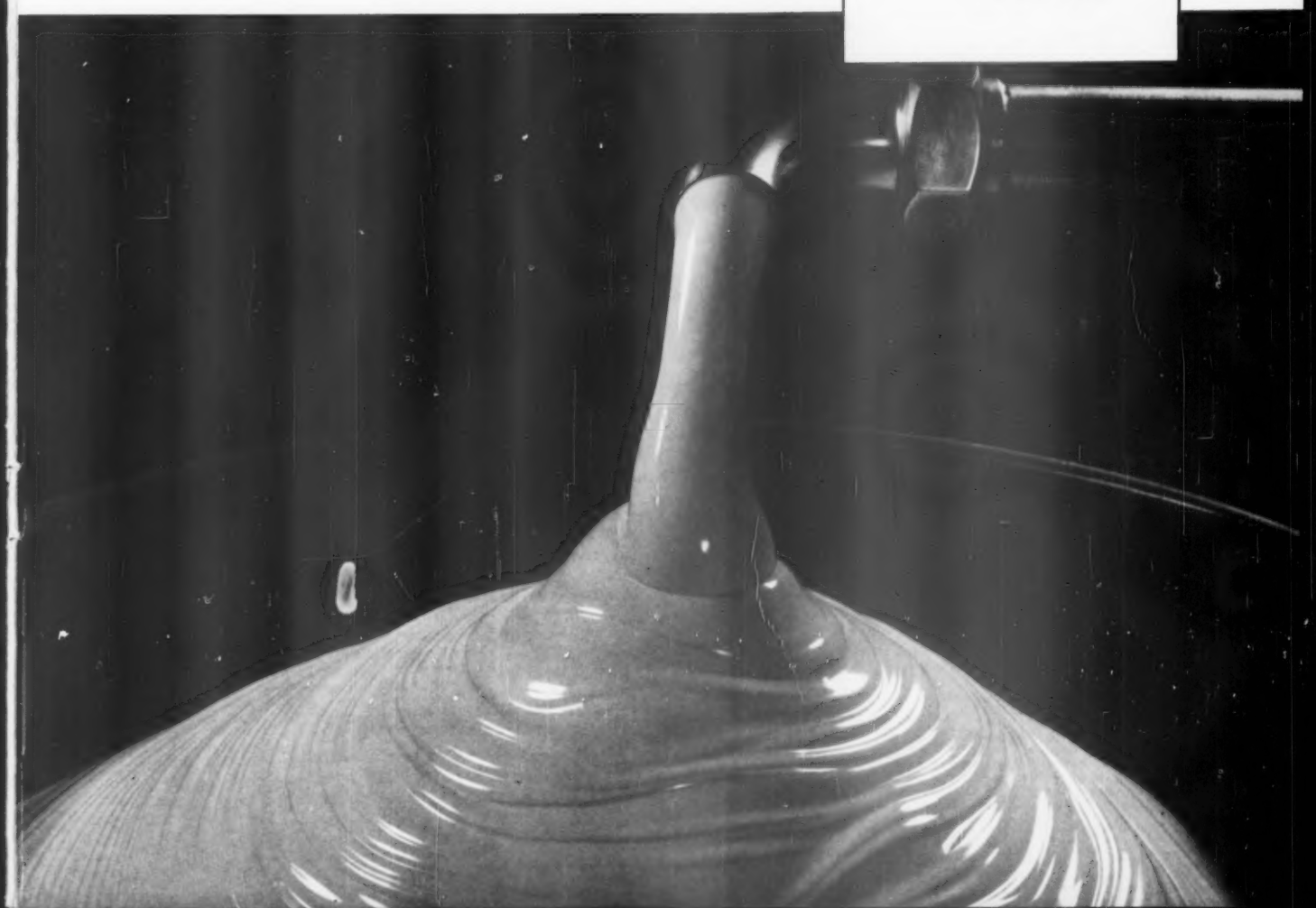

Books

(Continued from page 14 preceding technical papers)

war. Adverse criticisms are stated where the author is not in accord with activities of the agencies. Many actions by other governments, particularly the United States, are cited in comparison with those of the Government of Great Britain.

Food Technology is divided into two groups of disciplines, the nutritional and those which apply basic sciences, as chemistry, to preserving, transporting, packing, storing, coloring and flavoring. It is only recently that those specializing in the two groups have approached sympathetic understanding. While the major thesis is the technics of preserving etc., due attention is given to the impact of the changes of the properties of the commodities on nutritive values and public health. Processed foods are categorized into ten groups, Modern Bread, Meat, Fish, Chicken, Eggs, Milk Cheese and Ice Cream, Fats and Margarine, Sugar and Sweetness, and Fruits and Modern Jam as Chapters. In addition the subject is introduced by a discussion of the relation of the producers and scientists to foods, and closed with a discussion of the law (British) and good food.

The subject is interestingly presented and can well serve technologists to emphasize responsibility for the public health. It is probable that the author does not quite attain his objective of presenting his subject to the general reader as the rather free use of technical terms would appear to require an understanding not usual without science training. It is probable however that the intelligent "non-scientific" reader interested in what is happening to foods under modern technology can attain a better and more sympathetic understanding of both technical and legal problem procedures and actions.

HOWARD D. LIGHTBODY.

Selected Abstracts*

ANALYTICAL METHODS

Identification of stabilizing agents.

EWART, M. H., AND CHAPMAN, R. A. *Anal. Chem., 24,* 1460-4 (1952).

The development of a method for the identification of stabilizing and thickening agents used in food products. The materials studied were pectin, deesterified pectin, algin, Irish moss, gum tragacanth, gum karaya, locust bean gum, starch, agar, gum arabic, gum ghatti, carboxymethylcellulose, methylcellulose, and gelatin.

Quantitative paper chromatography of D-glucose and its oligosaccharides.

DIMLER, R. J. *Anal. Chem., 24,* 1411-14 (1952).

A procedure is described which is based on using the anthrone reaction for the colorimetric measurement of the constituents resolved by paper chromatography and eluted from the paper. The method potentially is of even wider applicability, because other hexose derivs. and polymers can be detd. with the anthrone reagent.

The electrophoresis and chromatography of plant viruses on filter paper.

GRAY, R. A. *Archi. Biochem. Biophysics, 38,* 305-16 (1952).

Tobacco mosaic virus was readily detected by paper chromatography. Electrophoresis on filter paper enabled the detection of tobacco mosaic virus, cucumber mosaic virus and potato virus.

Estimation of skin content of peanut meals and relative skin pigment content of isolated proteins.

STANSBURY, M. F., AND HOFFPAUIR, C. L. *J. Am. Oil Chemists Soc., 29,* 370-2 (1952).

A method for estg. the skin content of peanut meals and relative skin pigment content of peanut proteins is described. The results obtained indicate that the method may be used to est. the degree of skin removal in the prepn. of peanut meals and also to evaluate proteins for skin pigment content.

BIOLOGICAL SCIENCES

BIOCHEMISTRY

Intermediary carbohydrate metabolism.

LARDY, H. A. *Nutr. Observr., 13,* 43-6 (1952).

A brief review in two parts. The first deals with the processes by which the body obtains carbohydrate in the blood stream in a form which is available to the cells. The second section deals with the stepwise, enzymatically-catalyzed reactions by which the carbohydrates are combusted in the cell.

Inhibition and activation of orange pectinesterase.

EDWARDS, J. W., AND JOSLYN, M. A. *Archi. Biochem. Biophysics, 39,* 51-5 (1952).

Quant. data reported on the effect of various agents upon the activity of pectinesterase (PE) is summarized as follows: a) No effect on PE - potassium cyanide, cysteine hydrochloride, mercuric chloride, rhodium sulfite, and hydrogen peroxide. b) Decreases PE activity - silver nitrate. c) Increases PE activity - ascorbic acid and sodium bisulfite.

Inhibition of gastric secretion of hydrochloric acid in vivo by carbonic anhydrase inhibition.

JANOWITZ, H. D., COLCHER, H., AND HOLLANDER, F. *Nature, 170,* 499 (1952).

A heterocyclic sulfonamide which is 440 times more potent than sulfanilamide for the inhibition of carbonic anhydrase activity was injected into dogs. The acid secretion was inhibited for 24 hrs., with no observable toxic reactions at the end of this time.

A reaction of D-glucosamine in the presence of "dry" protein.

LEA, C. H., RHODES, D. N., AND BORRELL, S. *Nature, 169,* 1097-8 (1952).

Glucosamine, when freeze-dried from a mixed soln. of its hydrochloride with casein at pH 6.3 and stored at 37° C. and 70% relative humidity undergoes a rapid and extensive reaction in which the amino and aldehyde functions of the glucosamine mol. are simultaneously destroyed. The expected condensation of the aldo-sugar with the lysine ε-amino groups of the protein does not occur to any appreciable extent, and the lysine remains unaffected. A comparable phenomenon was observed when N-acetyl-D glucosamine was dried and stored in the same way with casein. The nature of the reaction products have not been investigated.

Interaction of macromolecules and fibrinogen.

FLETCHER, F., AND MARTIN, L. E. *Nature, 170,* 319 (1952).

Preliminary investigations indicate that the property of forming a complex with fibrinogen is not peculiar to dextran but is also possessed by polyvinylpyrolidone, gum acacia and laminarin, and since the complex formed contains only approx., 1% of the polymer in soln. and 10% of fibrinogen, it probably would have no pathol. significance.

Vitamin B_{12} measurement test developed by Pfizer.

Oil, Paint Drug Reptr., 162, 58, September 29, 1952.

The test involves addn. of sodium cyanide to the fermentation broth. The mixt. is allowed to stand long enough for the vitamin and drug to interact. Thereafter the spectrophotometer measures the difference between the visible spectrum of the vitamin and the spectrum of the dicyanide complex formed by interaction of B_{12} and sodium cyanide.

Irradiation damage and blood transfusion.

What's New, 8, September, 1952.

(Continued on page 21)

* These Selected Abstracts are made available to FOOD TECHNOLOGY through the cooperation of Associate Editor H. A. Campbell and the General Foods Corporation of New York, N. Y. The abbreviations found in these abstracts are similar to those used by Chemical Abstracts.

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PLASTICS & SYNTHETICS DIVISION

Abstracts

(Continued from page 18)

Anticipation that blood transfusion might be the answer to radiation injury is not supported by exptl. and clinical observation. Results from transfusions alone were in many respects the reverse of those anticipated, if extensive study of dogs may be extrapolated to human beings.

Bacterial survival in systems of low moisture content. III. Bacteria in fixed oils and fats. 1. Viable counts of micro organisms. 2. Effect of storage and bactericides on viability.

BULLOCK, K., AND KEEFE, W. G. *J. Pharm. Pharmacol., 3,* 700-33 (1951); *Brit. Abstracts, A III,* 1085 (1952).

III. 1. Cells of *Streptococcus faecalis* and spores of *Bacillus subtilis* were evenly distributed in oils and fats by use of spray-dried peptone powders of the organisms. Spores of *B. subtilis* free from a layer of dried peptone were obtained after dehydrating with acetone followed by spray-drying in a soln. of stearin in acetone. When this powder was added to the oil the stearin dissolved leaving the spores in suspension in the oil. A technic is described for the performance of viable counts on oils and fats. Statistical analyses and recovery expts. showed the counting technics to be accurate usually within the limits of approx. ± 10%. III. 2. Spores of *B. subtilis* remained viable in oils and fats and liquid paraffin for over 2 years. *Strep. faecalis* remained viable in similar substances for 6 months. It is concluded that the only effect of the oils was to provide a medium which preserved a low moisture content. No evidence of the multiplication of *Strep. faecalis* or the germination of spores of *B. subtilis* in oily media was found. None of the bactericides tested had any action on the suspended organisms. The possibility that other spores and bacteria might possess similar resistance and the bearing of this on the dispensing of oily solns. for injection is discussed.

The hydrolysis and excretion of polymeric phosphate.

GOSSELIN, R. E. *J. Pharmacol. Exptl. Therap., 106,* 180-92 (1952).

Two linear phosphate polymers were extensively hydrolyzed to orthophosphate in rats and rabbits. In contrast two cyclic polymers suffered almost no hydrolysis and were promptly recovered as intact mols. in the urine. Studies on linear or open-chain compds. showed that tripolyphosphate was more rapidly and more extensively degraded *in vivo* than its homologue with six atoms of phosphorus (labelled hexametaphosphate). The dose, route of administration, and assocd. cation all influenced the extent to which unhydrolyzed polymer escaped in the urine. Sodium salts of tripolyphosphate and hexametaphosphate were more rapidly mobilized from sites of injection and provided larger amts. of polymeric phosphate in the urine than did the corresponding calcium salts. Although the cyclic polymers trimeta- and tetrametaphosphate were excreted virtually unchanged after parenteral administration, a small fraction of injected trimetaphosphate was converted to orthophosphate in rats and rabbits. All four polymers appeared to be hydrolyzed when given by the oral route. Tissue sites of these enzymatic hydrolyses were not identified; no activity was present in blood or urine.

Effect of propylene glycol on intravenous toxicity of dissolved compounds.

HORTON, R. G., AND CONN, L. W. Chemical Corps Med. Labs., Army Chemical Center, Md. *Federation Proc., 11,* 73 (1952).

In detg. the injection toxicity of many compds., propylene glycol (PG) is a satisfactory vehicle due to its low toxicity, to its solvent action on many compds. sol. in either water alone or fat solvents alone and to the absence of hydrolysis of the solute. However, PG affects the toxicity of the solute when injected intravenously (i.v.) in small animals in the vol./kg. necessary for accurate measurement of doses. The necessary volume in mice is about 2.5 mL/kg. By itself, such a volume of PG injected via the lateral tail vein over a 4-second period produces severe transitory symptoms in most mice and very rapidly ensuing death in an av. of about 6%. The i.v. toxicity to mice of various compds. in PG and in water has been compared to est. whether PG affects their toxicity enough to preclude its use as the standard solvent of choice for i.v. toxicity work on small

(Continued on page 22)

1. *Effective antioxidant*
2. *Readily soluble*
3. *Tasteless, colorless, odorless*
4. *Physiologically harmless*
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6. *Good "carry-through"*
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*Higgins and Black, Oil & Soap, Vol. XXI, No. 9, 1944.

Sustane 1-F

Abstracts

(Continued from page 21)

animals. Expressed as percentage, certain compds. were less toxic in water than in PG: DFP and NaCN, 20%, strychnine sulfate, 55%. Others were more toxic in water: atropine sulfate, 17% nicotine alkaloid, 58%.

Chemicals in foods: A report to the Association of Food and Drug Officials on current developments. Part II. Pesticides.

LEHMAN, A. J. *Assoc. Food Drug Officials, 16,* 85 (1952).

The article summarizes studies on the accumulation of some of the chlorinated insecticides in the fat of rats and dogs, their rate of disappearance, and the influence of certain org. phosphates on the cholinesterase enzyme system.

NUTRITION

Soil fertility and human nutrition.

MAYNARD, L. A. *Farm and Home Science, 13,* 66-7 (1952).

The importance of the soil in relation to mineral nutritional needs of animals is not comparable to the case of human nutritional needs. It has not been proven that any human diseases are caused by soil deficiencies. Soil effects do not directly influence the nutritive value of meat or other animal products, (eggs or milk) providing over 30% of the calories of human diet, nor do they influence cereals making up another 30% of the diet. However, soil conservation and improvement still require much research as they will provide more nutrients per acre.

Meat in the diet of infants and young children.

Current Med. Digest, 19, 105-06 (1952).

Hemoglobin and red cell values of infants who received meat increased above those who served as controls during a 4 mo. period and dropped when the meat was discontinued. The incidence of colds was reduced among the meat fed infants. Sleep habits improved and children appeared better satisfied than babies not fed meat. A similar study appearing in the J. Am. Med. Assoc. in 1951 also stated that a meat diet alleviated upper respiratory tract infections in children.

Geriatric nutrition.

Federation Proc., 11, 775-97 (1952).

A symposium including papers on: "Intakes and retentions of nitrogen calcium, and phosphorus by 136 women between 30 and 85 years of age," "Changes of body composition in man during maturity and their nutritional implications," and "Fundamental considerations, old and new, in nutrition of the elderly."

Senile anorexia.

VINTHER-PAULSEN, N. *Geriatrics, 7,* 274-9 (1952).

Symptoms of nutritive failure (glossitis, cheilities) are very common among weak old persons living by themselves. The daily food consumption of a group of patients with these symptoms was analyzed and found to be definitely deficient compared with that of a control group of normal, active old persons. Thorough clinical examn. (and in some cases autopsy) revealed no malignant disease, chronic infections, or intoxications to account for the decreased intake of food. Studies of the case histories seem to suggest that senile debility may be caused by a primary disturbance of appetite regulation associd. with various medical, psychological, and sociological factors which are peculiar to old age and which tend to reduce either quantity or quality of the food consumed.

Build up liver to check old age diseases.

Science News Letter, 62, 184 (1952).

Methiscol, a drug contg. choline, inositol, methionine, and vitamin B_{12} has been found effective in improving or restoring liver function to normal in aged persons. A daily dose of the first three chems. also tended to restore to normal the ratio of large fat particles to total fatty particles in the blood. This may help to check hardening of the arteries.

Atherosclerosis and the diet.

RUTLEDGE, D. I. *Current Med. Dig., 19,* 23-4, October, 1952.

It is not known if an excess intake of cholesterol-contg. foods leads to a deposition of fatty material in the coronary arteries which tends to soften and provide a locus for clot formation. It has been shown that large lipo-protein mols. present in the fatty deposit are still formed after a restriction in cholesterol food intake because the animal body can synthesize cholesterol from shorter fatty acid radicals. Therefore weight reduction and reduction of total fat intake is important for patients having coronary atherosclerosis.

Vitamin B_{12} and antibiotics in animal nutrition.

WAKELAM, J. A. *Mfg. Chemist, 23,* 375-8 (1952).

Antibiotics in feeds raise the general level of metabolism if used from a fairly early stage. They may also contribute to curing of diseases present at the subclinical level. Growth promotion from antibiotic activity depends on the changes in the microbial population of the gut in which harmful organisms may be suppressed; organisms which compete with the host for food are suppressed by reducing the competition, beneficial micro-organisms may increase. It has been repeatedly demonstrated that the effects of antibiotics and vitamin B_{12} are entirely sep. and are, in fact, additive.

FOOD AND FOOD TECHNOLOGY

BAKING AND BAKERY PRODUCTS

How bakery products react to low temperature freezing. Part III.

GLABAU, C. A. *Bakers Weekly, 155,* 44-6, September 29, 1952.

Report on the effect of freezing pound cake at from 10° above to 20° below zero: 1. Restricts volume of cake. 2. The lower the freezing temp. the greater will be the absorption of water when thawed out.

Chemical composition and structure of fats in relation to their value for cake making.

MAHADEVAN, V. *A. R. Hormel Inst., 27,* 1950-51; *Brit. Abstracts, B III,* 423 (1952).

Preliminary dilatometric studies of mixts. of pure synthetic triglycerides have demonstrated the existence of hitherto unreported phase relations in mixt. of tristearin and triolein.

CONFECTIONERY

A report on candy research.

EASTON, N_A R., AND MOLER, E. S. *Confectioners J., 78,* 22-4, October, 1952.

A brief report on the use of modifiers to retard fat-bloom in chocolate. The use of G-2034 (60% Span 60 + 40% Tween 60) in enrobing tests, under plant conditions indicated that the shelf-life could be increased 4-fold.

FISH

The effects of different methods of preservation on the nutritive factors in fish.

Industrial Memorandum No. 15 (Fisheries Research Board of Canada, Pacific Fisheries Experiment Station); *World Fish. Abstracts, 43,* May-June, 1952.

Review of the effects of freezing, cold storage, cold smoking, salting, i.e. preservation methods not involving previous cooking, on the nutritive factors of fish, as well as of the methods involving pre-cooking, i.e. canning, hot smoking, and dehydration of cooked fish. The effects of cooking before use are reviewed separately.

Chemical studies on the substance of fish smell. II. Pyridine group compounds as the substances concerned with fish smell.

OBATA, Y., YAMANISHI, T., AND ISHIDA, M. *Bull. Japanese Soc. Scientific Fisheries, 15,* 551 (1950); *World Fisheries Abstracts, 3,* 45, May-June, 1952.

Although trimethylamine is known to be the source of off-odor in stale sea fish, the odor of fresh water fish is not due to trimethylamine, but presumably originates from the mucilage on the skin. When herrings were wiped with gauze, the gauze did not smell if it was dried rapidly, but when it was left wet, the odor which developed after a few hrs. was identical with the odor from fresh water fish. Water from a carp culture pond was concd. and its odor resembled that of pyridine; pyridine gave a positive reaction with p-quinone. Aminovaleraldehyde

(Continued on page 24)

New food laboratory vital part of expanded Eastman service

Troubled by rancidity? changes in odor or flavor? discoloration? brittleness?

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If you are having difficulty in holding food quality to specifications because of oxidative deterioration, send an adequate sample with a statement of the problem to Eastman Chemical Products Inc., Chemicals Division, Kingsport, Tennessee.

1. Checking appearance of unstabilized lard during AOM analysis.

2. Bank of Schaal ovens employed for accelerated shelf life tests for all types of food products.

3. Experimental paper coating machine to assist manufacturers on problems relating to rancidity and spoilage caused by oxidation.

4. Eastman food chemist dissolving antioxidant in blended shortening.

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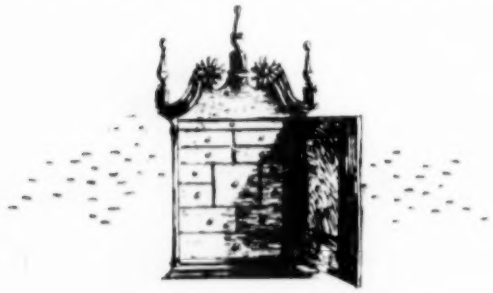

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Abstracts

(Continued from page 22)

and aminovaleric acid, which are produced by oxidation of pyridine, also had a fish odor.

Chemical studies on the substance of fish smell. III. Investigation on the components of mucilaginous substances of salmon.

OBATA, Y., AND YAMANISHI, T. *Bull. Japanese Soc. Scientific Fisheries, 15,* 554 (1950); *World Fisheries Abstracts, 3,* 45, May-June, 1952.

Picrolonic acid was added to mucilage obtained from the skin of salmon. The resulting picrolonates were examd. microscopically; the picrolonate of aminovaleric acid was identified and 2 other compds. were detected. From expts. attempting to reproduce artificially the materials responsible for fish odor, the following conclusions were reached: Fresh fish odor arises from the presence of piperidine and the reaction product of piperidine and acetaldehyde; the condensed mixts. of these substances smell like fresh-water fish, and when trimethylamine is added, the mixt. smells like sea fish. In stale fish, aminovaleric acid is present as well, and if staleness is more advanced methylmercaptan and indole are present.

Whale meat.

Espana Pesquera (Alcala 31, 4° Piso, Madrid, Spain), 1, 2, 8, May, 1950 (in Spanish); *World Fish. Abstracts, 3,* 21, July-August, 1952.

A whale weighs 80 to 100 tons, the equivalent of 300 oxen; it yields approx. 46.3% of its total wt. in meat and 23% in oil. From the tongue of an adult whale, it is possible to recover 6 barrels of fat weighing 100 kg. (220 lbs.) of each. The quality of whale meat varies according to its age. In the young cetacean it is light pink, but it darkens with age. The lighter pink meat is more tender and has a better flavor. When the whale has reached its sexual maturity the meat gets a slightly disagreeable flavor called "whale taste." However, if canned, this taste disappears and the product resembles beef. According to observations, the odor comes from the oxidation of fats and from putrefaction when whales are not eviscerated soon after having been killed. Recently, consumption of whale meat has increased considerably. If it is caught for human consumption, the harpoon should be shot into the base of the neck to bleed the whale completely to get a lighter meat. By hydrolysis of the whale meat proteins, Okuda and Kimoto obtained 4.66% alanin, 6.25% valine, 3.54% leucin, 0.49% serine, 1.51% proline, 3.28% glutaminic acid, 1.47% aspartic acid, 2.40% tirosine, 6.48% arginine, 0.48% lisine, 3.55% histidine and traces of triptophane. The nitrogen content consists of: sulphuric acid sol. N, 15.99%; imido-N, 0.51%; basic org. N.5.18%; N from monoaminoacids, 9.39% and sulphuric acid insol. N, 0.72%.

FRUIT AND VEGETABLES

The isolation and identification of quercetin and isoquercitrin from grapes (Vitis vinifera).

WILLIAMS, B. L., AND WENDER, S. H. *J. Am. Chem. Soc., 74,* 4372-3 (1952).

Grapes, *Vitis vinifera,* have been reported to possess a relatively high "vitamin P" activity, attributed to the flavenoids present. Quercitin (3,3', 4', 5, 7 pentahydroxyflavone) and isoquercitrin (quercitrin-3-glucoside) have been isolated and identified by hot water extn., ion exchange chromatography, concn. and vacuum drying. White seedless, tokay and emperor grapes were used.

How silicone compounds are making tomato catsup history.

Canner, 115, 16, 22, October 4, 1952.

Silicone compds. are used for keeping filling nozzles from sticking to bottle necks, from killing foam during bottling, in preventing burn-on of tomatoes to steam-cooking coils and eliminating hours of scrubbing from clean-up schedules. One special type of silicone is popular with freezers of vegetables. This product keeps peas and corn from adhering to freezing trays. One type of silicone grease makes possible easier working car wheels and doors in Alaska fish canneries.

(Continued on page 27)

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Write to nearest regional secretary, if within an area covered by a regional section, or to the Executive Secretary of the Institute, for an application form and information regarding qualifications and classifications.

Abstracts

(Continued from page 24)

Histological study of ice formation in frozen vegetable tissues.

Maurer, A. R., and Murray, H. R. *Sci. Agric., 31*, 519-29 (1951); *Brit. Abstracts, B III*, 354 (1952).

Asparagus, beans, beet-tops, and peas frozen slowly, with consequent formation of large ice crystals, are not inferior on final analysis to similar vegetables frozen at more rapid rates.

Reducing sugar content of Maine-grown potatoes treated with maleic hydrazide.

Highlands, M. E., Luciarello, J. J. and Cunningham, C. E. *Am. Potato J., 29*, 225-7 (1952).

Potatoes of Kennebec and Katahdin varieties when treated with maleic hydrazide show no significant reduction in accumulation of reducing sugars compared with untreated controls when stored at 40° F. for six months. Appearance and color of potato chips prepd. from like samples show no significant differences within the variety.

Increase sugar in sugar beets.

Science News Letter, 62, 103 (1952).

By applying growth-regulating sprays as maleic hydrazide to sugar beet plants shortly before harvesting, higher sugar concns. in the beets can be maintained. Low sugar contents may be due to continued active growth or to excessive seed stalk production by the plants, which tend to use up sugars instead of storing them.

GELATIN

Plasma expanders.

Rawdin, L. S. *J. Am. Med. Assoc., 150*, 10-13 (1952).

A satisfactory plasma expander must have an oncotic (swelling) effect equal to that of plasma; it must remain in the circulation more than a few hrs.; it must be readily metabolized and easily excreted; it must have no antigenic or allergenic effects, not be harmful to visceral functions, or not interfere with typing or cross agglutination of blood, and it must be capable of being cheaply prepd. from substances constantly available. The question remains whether the norm ovolemic or hypovolemic patient should be used in evaluation of plasma expanders. As expanders gum acacia and pectins have been discarded because they are stored in the tissues with harmful effects, blood derivs. are hard to stockpile (except for human globin, which can be lyophilized and remains stable) and the value of polyglucose and glucomer has not been established. Dextrins, which also differ individually, are being studied for allergic reactions, and to produce a more uniform product with a narrower spectrum of mol. wts. Polyvinylpyrolidone has given favorable results, however, a certain percentage of the material is stored for long periods of time. The main disadvantages of osseous gelatin are: (a) the unexcreted portion may not be metabolized (not certain), b) gelatin interferes with blood typing and cross matching, c) it gels at room temp. Modified gelatin, oxypolygelatin has given favorable results and also heat degraded gelatin, modified by use of coupling agents.

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Although the new bibliography contains primarily abstracts of papers published in 1950 and 1951, it also presents some abstracts of papers mentioned only by title in the previous volume along with some new entries from the 1940's which were located last year.

In this volume, entries are arranged by the same outline that was used before. Again, as in the previous volume, the abstracts are intended to summarize the principal results reported. Abstracts are grouped under the following headings: occurrence and distribution, determination, chemistry, physiology, and pathology, pharmacology, nutrition and metabolism, medical and therapeutic use, and veterinary use.

In the preface to this second volume, Norris Embree, Director of Research, Distillation Products Industries, notes:

> "Vitamin E was one of the first known vitamins. It may still be fair to call it one of the least known, at least as to its role in human physiology. But the function of tocopherol is, as can be seen by these bibliographies, a subject being studied with diligence by biological, chemical, and clinical investigators."

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FUTURE DATES FOR FOOD TECHNOLOGISTS

1953	
Feb. 11-14	Institute of American Poultry Industries, Kansas City, Missouri
Feb. 19-20	Winter Meeting of the National Pickle Packers Association, Chicago, Illinois
Feb. 21-25	National Canners Convention and Canning Machinery and Supplies Association Show, Chicago, Illinois
March 1-6	National Frozen Food Convention, Chicago, Illinois
March 2-4	Quality Bakers of America, Chicago, Illinois
March 2-6	American Society for Testing Materials, Detroit, Michigan
March 8-11	American Institute of Chemical Engineers, Biloxi, Miss.
March 9-13	Statistical Quality Control School, University of Maryland, National Canners Association, Tri-State Packers, College Park, Maryland
March 15-18	One hundred and twenty-third National Meeting of the American Chemical Society, Los Angeles, California
March 19-20	National Collegiate-Industry-Government Conference on Instrumentation, Michigan State College, East Lansing (Invitational: Address Electrical Engineering Dep't., Michigan State College, East Lansing, Mich.)
March 22-24	American Dairy Association, Chicago, Illinois
April 6-10	American Society of Biological Chemists, Chicago, Illinois
April 6-10	American Institute of Nutrition, Chicago, Illinois
April 20-22	American Management Association, National Packaging Exposition, Chicago, Illinois
April 20-22	National Frozen Food Industries Exposition, New York, N. Y.
June 21-25	**Thirteenth Annual Meeting of the Institute of Food Technologists, Boston, Massachusetts**

(Information concerning future dates of national and international meetings, conventions and exhibits of interest to food technologists should be sent to the editorial office.)

ATTENTION: RESEARCH WORKERS ON FISHERY PROBLEMS

There is a need for a limited number of research papers for presentation at the fishery session of the annual meeting of the IFT to be held in Boston, Monday, June 22. Presentation time will be limited to about ten minutes in order to allow for an adequate discussion period. Those wishing to submit titles and abstracts are requested to forward them at the earliest possible moment to H. L. A. Tarr, 898 Richards Street, Vancouver 2, B. C., Canada, so that they may be included in the program.

Obituary

On December 27, 1952, death came to Dr. Mary E. Pennington, eminent consultant with a long and illustrious career in food science. Dr. Pennington was among the very first American women to achieve doctorates in the scientific field. During her life she served in a number of distinguished positions—in the United States Department of Agriculture, in industry, in the War Department during World War II as an expert consultant, and in the professional societies of America. Dr. Pennington will be remembered for both her professional achievements and her personality. She was known, with affection and respect, in virtually every scientific organization with interests in the food field in America and her reputation extended beyond the borders of America.

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Directory of Members 1952-1953

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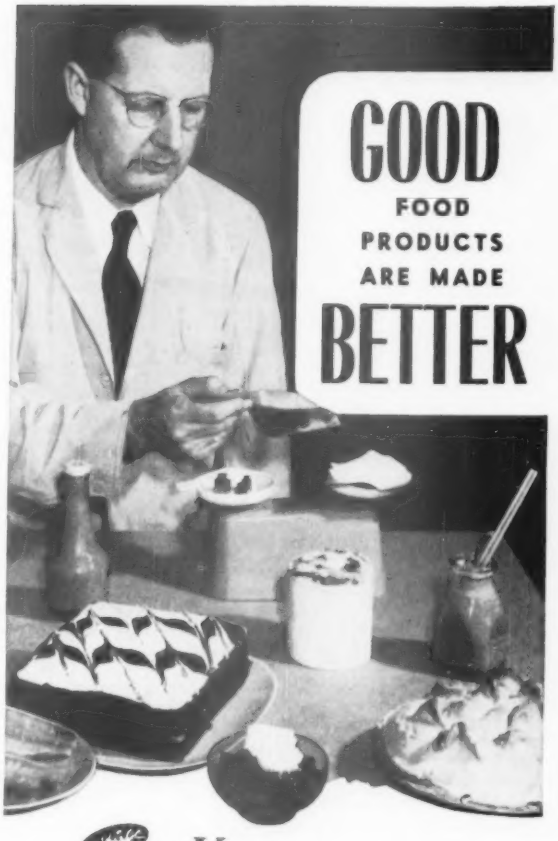

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- Improving mouth feel and flavor
- Increasing efficiency of component ingredients
- Modifying ice crystal growth
- Physical and anti-oxidant protection

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134

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EMPLOYMENT NOTICES

AVAILABLE: Food Bacteriologist Ph.D. 27, research experience, background in biochemistry, desires position investigating microbial problems in food spoilage, packaging, freezing, preservatives and antibiotics. Will consider academic position. REPLY BOX 238, Institute of Food Technologists, 176 W. Adams St., Chicago 3, Ill.

WANTED: Food Technologist—for diversified development work in ice cream in frozen food field. Prefer person with good academic background with approximately 5-10 years industrial experience. Location NYC. Large food manufacturer. Write resumé. REPLY BOX 249, Institute of Food Technologists, 176 W. Adams St., Chicago 3, Ill.

ADVANCED FATS AND OILS CHEMIST

One of the Mid-West's largest food processors offers opportunity to an advanced fats and oils chemist. Excellent technical background with initiative and perseverance essential. Require advanced study or laboratory work in Shortening or practical experience in Shortening. Excellent future and good starting salary for man with qualifications. REPLY BOX 245, Institute of Food Technologists, 176 W. Adams St., Chicago 3, Ill.

ADVANCED BIOCHEMIST

If you have an excellent technical background in the food field, one of the Mid-West's largest food processors offers an opportunity in their expanding Research Department. Need man with initiative and good background to work primarily in project research applied to meat products. Good starting salary commensurate with experience and advancement opportunity. REPLY BOX 246, Institute of Food Technologists, 176 W. Adams St., Chicago 3, Ill.

WANTED: Recent graduate in food technology or food engineering. To supervise the study of preparation and canning of products using recently developed aseptic methods. Good opportunity. REPLY BOX 242, Institute of Food Technologists, 176 W. Adams St., Chicago 3, Ill.

WANTED: Recent graduate with training in chemistry and/or food technology for general laboratory and pilot plant work with food materials. Good opportunity. REPLY BOX 243, Institute of Food Technologists, 176 W. Adams St., Chicago 3, Ill.

FLAVOR CHEMIST—Leading essential oil house requires services of man with experience in the formulation of imitation and true fruit flavors. REPLY BOX 248, Institute of Food Technologists, 176 W. Adams St., Chicago 3, Ill.

AVAILABLE: Food Technologist. B.S. in Chemistry, 1½ yrs. graduate study, 7 yrs. experience in processing and research. Desire position in research, production or technical sales. Preferred location radius 100 miles New York City. REPLY BOX 251, Institute of Food Technologists, 176 W. Adams St., Chicago 3, Ill.

AVAILABLE: Food Chemist, Seasoning Specialist. 1943 graduate, age 31, broad background in flavors, extracts, spices, desserts, specialties, etc. Experienced in production, control, research, formulation, flavor matching, customer technical services. Creator of several nationally distributed items.

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REPLY BOX 250, Institute of Food Technologists, 176 W. Adams St., Chicago 3, Ill.

AVAILABLE IMMEDIATELY: BIOCHEMICAL ENGINEER. Ph.D. January 1953, M.S. B.S., Ch.E., biochemistry, engineering, microbiology, and statistics. 8 yrs. diversified teaching, research, and industrial experience. Fermentations, vitamins, and scale-up. Desire half-time teaching and research or full time industrial research. Married, 32, veteran. Honor societies and publications. REPLY BOX 247, Institute of Food Technologists, 176 W. Adams St., Chicago 3, Ill.

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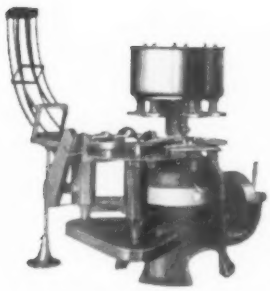

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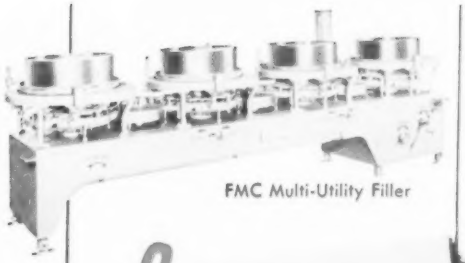

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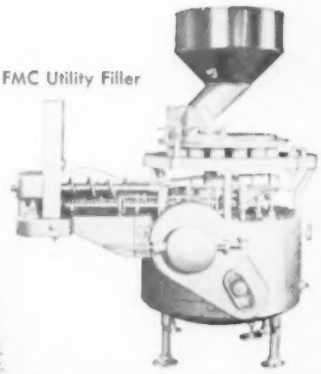

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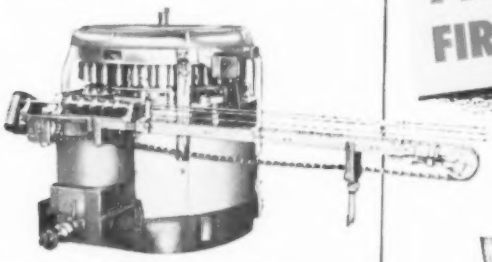

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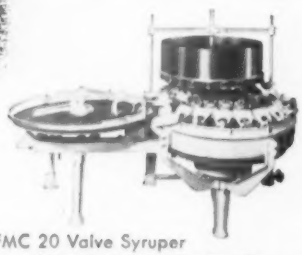

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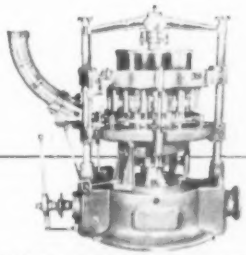

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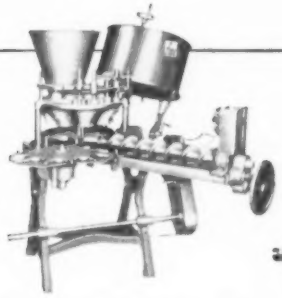

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